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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

BULLETIN No. 5.

THE FORESTS, FOREST LANDS, AND FOREST PRODUCTS OF EASTERN NORTH CAROLINA.

BY

W. W. ASHE,

IN CHARGE OF FOREST INVESTIGATION.

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., September 26, 1894.

To his Excellency, HON. ELIAS CARR,
Governor of North Carolina.

SIR:—I have the honor to submit herewith for publication as Bulletin No. 5 of the Geological Survey publications a preliminary report on the Forests, Forest Lands and Forest Products of Eastern North Carolina. This report has been prepared by Mr. W. W. Ashe, who is making for the Survey a careful examination of the forests of the State. I beg to call your special attention to two facts brought out in this report: (1) the continued and unnecessary destruction of the forests of our eastern counties by fires and stock, and the importance of remedying this evil before it is too late; (2) while we cannot at once greatly enlarge the areas of our turpentine orchards the quality and value of the naval store products may be increased to the extent of some $200,000 per annum by the adoption of the French system of gathering the turpentine.

I desire to express my appreciation of the active and encouraging interest which you and the other members of the Board have shown continuously in this and all other work undertaken by the Survey.

Yours obediently,
J. A. HOLMES,
State Geologist.

PREFACE.

The law inaugurating the Geological Survey provides for the investigation of the timber as well as the mineral interests of the State; and in carrying out this provision a systematic examination of the forests was begun in 1891 and has been carried on since that time. The plan adopted in this work embodies a fourfold investigation: first, as to the existing forest resources; second, as to how these resources can be utilized to the greatest advantage without involving the destruction of the forests; third, as to how the waste lands of the State can be continuously restocked with valuable trees, and thus our forest wealth perpetuated; and fourth, as to what can be done to encourage the development in the State of enterprises which will manufacture into finished products a larger portion of our timber instead of shipping to other States our crude materials for manufacture there. We have found, as will be shown in this Report and others which are to follow at an early date, that our forest resources are considerable; and they are now attracting lumbermen and capital from many sections of the country. The lumbering industry in the State is already a large one and is increasing in magnitude; indeed, already the timber is being cut with such rapidity that we may fairly ask ourselves the question, how long it will be before our forest wealth, like that of many other States, becomes a matter of the past. And we may also ask ourselves the question, whether it is possible that these resources can be utilized now and at the same time our forest wealth be perpetuated.

A trained student in forestry will answer this latter question in the affirmative, but the experience of the past has too often answered it in the negative. The cutting of the valuable timber frequently leads to the total destruction of the forest. The trees are felled regardless of surrounding growth that may be injured; and the branches and the tops are left scattered among the younger growth and thus add greatly to the destructiveness of forest fires, which frequently follow during the first dry season. The average lumberman has but one purpose in the prosecution of his work: the removal of the valuable timber. It rarely happens that the owner, himself, seriously considers the future welfare of his forests; and, indeed, the opinion seems to be prevalent in the public mind that when the valuable timber has been once removed from a forest the forest itself no longer has a value, and may as well be cleared away so that the soil can be cultivated; or, if it is allowed to remain, it is usually made to serve as a range for cattle, and is thought to answer this purpose best when burned through by the forest fires every autumn or spring.

The policy of the average citizen appears to be based upon the theory that our natural resources are inexhaustible, and that we should get all out of them we can to-day and let the future take care of itself. And so thoroughly grounded are these notions in our public and private policy that it is exceedingly difficult to secure the adoption of any plan which runs counter to them. But fortunately, in the matter of our forests, their preservation for use by a future generation need not prohibit the utilization of the valuable timber now standing by the present generation. It only demands that while we cut and make use of this timber we protect the young growth, and look to the restocking of our waste lands with valuable trees, and thus make the forest valuable for future generations also.

The examinations of the forests in Eastern North Carolina were begun by the present writer several years ago. More extended investigations have been carried on by Mr. W. W. Ashe at intervals during the past two years. The larger part of the information embodied in the present report was collected by him during a series of extended trips made through the eastern counties during the autumn of 1893 and the following winter. As shown in the body of this Report, the approximate supply of pine timber now standing in Eastern North Carolina is about 8,200,000,000 feet, and this is being cut at the rate of about 450,000,000 feet per annum. These figures point in unmistakable terms to the fact that, unless meanwhile we encourage the growth of new trees, two decades more will find the valuable pine forests of this region largely a thing of the past. And it is unfortunately true that the cutting of this timber is often followed by the destruction of the forest.

Indeed, nothing in the way of forest management could be more reckless and destructive than the treatment of our long-leaf pine forests during the past few decades. In the boxing for turpentine the trees have been cut so deeply and so extensively that both their vitality and strength have been greatly weakened, and the storms have prostrated many of the finest specimens. The lumberman and the storms have been followed by forest fires, which have completed the destruction, already begun in so systematic a manner, of large areas.

Started at times by thoughtless hunters at night, by sparks from an engine, by careless squatters or tenants, or even at times by land owners, in the hope of improving the grazing capacity of their lands during the following season, these forest fires sweep irresistibly across miles of territory, destroying not only the mature forest trees, but also the young growth; and thus destroy the forest of the future as well as of the present. And the few young pines which may have escaped destruction in this way soon follow the fate of the others by being destroyed by hogs. Many of these long-leaf pine lands which lie in the sand hill regions of Eastern North Carolina have had their forest removed so completely that they have become "waste lands," covered by a thin growth of nearly worthless scrubby oak. The total area of these waste lands is now nearly half a million acres, and is steadily increasing. This Report endeavors to show that while much of these waste lands are worthless for other purposes, they can be re-set with long-leaf pine forests if they can only be protected against forest fires and stock. And it is gratifying to find among the lumbermen themselves a growing realization of the fact that it is to their interest and to the interest of the public at large that this destructive policy give place to a more intelligent plan which, while it does not seriously curtail the utilization of the existing forests, it looks to their protection and perpetuity.

It is devoutly to be hoped that this awakening will grow into a change of both public and private opinion concerning the future of our forests, and lead to the adoption and carrying out of rational plans for their perpetuity and improvement. The problems connected with the accomplishment of this end will be discussed more fully in future publications of the Survey, now in preparation. The object of the present report is to describe briefly the present condition of the forests and forest lands of this region. The capital invested in the lumber industry in Eastern North Carolina in 1893 amounted to $4,690,000, and more than 8,000 men were regularly employed in connection with the 323 establishments. The market value of the forests products of this region for 1893, including naval stores, but not including fire-wood nor fencing material, amounted to $7,320,000. Including these latter items the aggregate annual value of the forest products of the region will probably reach $12,000,000. Certainly this is an industry the future maintenance of which deserves the earnest consideration of the State and her individual citizens.

The Survey is indebted to many lumbermen, naval store dealers and manufacturers, and to many other citizens in every part of this region for their kind co-operation in the work of collecting information for this Report, and I beg to assure them that their kindness and hospitality have been highly appreciated.

J. A. HOLMES,
State Geologist.

FORESTS, FOREST LANDS AND FOREST PRODUCTS OF EASTERN NORTH CAROLINA.

By W. W. Ashe.

CHAPTER I.

FORESTS AND FOREST LANDS.

OBJECTS OF THIS PRELIMINARY FOREST SURVEY.

During the present decade there has been a marked increase in the lumber industry in Eastern North Carolina and a corresponding decrease in the available supply of standing timber. Already predictions are numerous as to the exhaustion at an early date of the supply of merchantable long-leaf pine over considerable areas. The boxing of these pines weakens the trees and makes them more liable to be blown down by the winds, and far more liable to be destroyed by forest fires, which by their frequency and extent have entirely removed the long-leaf pine forests over many large areas. These pine forests, in the sandy regions, instead of being replaced by a valuable young growth of the same kind are followed by a worthless growth of sand black-jack oak. Forest fires and subsequent pasturing of these regions with cattle and hogs are the important agencies which combine to prevent the long-leaf pine from reproducing itself over the larger portion of these sandy lands. From these causes the extent of these areas of waste or abandoned lands is increasing steadily. It is believed that under proper management these waste lands can be restocked with long-leaf pine.

The present examination was undertaken with a view to determining the exact condition of the forests of the eastern section of the State, the rapidity with which they are being removed, the condition of lumbered districts, the character, extent and condition of the regrowth or "second growth," and to find out, if possible, some practicable plans for the protection, development, and extension of the forests of this region.

AREA UNDER CONSIDERATION.

The area examined embraces thirty-eight eastern counties and the eastern parts of six more, being what is usually termed the long-leaf pine belt in North Carolina. This is the "coastal plain region" of the geologists, which extends inland from the coast a distance of one hundred to one hundred and fifty miles and has in this State an aggregate area approximating 24,000 square miles. Its western border, separating the hill country from the coastal plain region, may be described as an irregular line extending through the western part of Halifax and the south-eastern part of Franklin county, passing near Raleigh and Cary to northern Montgomery and eastern Anson counties. Its surface is that of a gently undulating plain, of less elevation (ten to twenty feet above tide) and of a more nearly level surface eastward, becoming more elevated (three hundred to five hundred feet) and rolling along its western border. Its soil is generally a sandy loam or sand, though in limited areas clay predominates. In the more eastern portion of this region are numerous extensive swamps or marsh areas surrounding, in some cases, small lakes and bordering streams. In some of these the soil is mainly an admixture of sand and vegetable *mold*, while in others it is a fertile loam. The soil of the western portions of this region, north of the Neuse river, varies considerably, but is ordinarily a loam, becoming sandy or gravelly in some places and clayey in others, while south of Neuse river the sand predominates, and there are numerous elevated, dry, sandy ridges on which only the long-leaf pine and the sand black-jack oak flourish.

KINDS OF GROWTH.

The timber over the entire section is, on the highlands, largely of two species of pine, one, the loblolly pine (*Pinus Taeda* L.), more confined to the counties north of the Neuse river and to the moister soil; the other, the long-leaf pine (*Pinus palustris* Mill.), to those south of this river and to the drier, more sandy soil. Beneath these trees, where the soil is not too dry and sandy, is a lower growth of small white and post oaks, dogwood, haws and the narrow-leaved crab-apple, while where the soil is very sandy and dry there grows, either with the long-leaf pine, or where it has been removed, a small worthless oak, the sand black-jack or barren oak (*Quercus Catesbaei* Michx.), and less frequently the high-ground willow oak (*Quercus cinerea* Michx.). This oak is also a small tree and indicates the most barren soil. Besides the pines just referred to, there are two others found with them, the short-leaf pine (*P. echinata* Mill.), an uncommon tree except on dark loam or gravelly soil along the western and northern limits of this section, and the savanna pine (*P. serotina* Michx.), a knotty, unsymmetrical tree occurring from Virginia southward along the margins of "pine barren" ponds or scattered in small clumps over the open savannas and marsh lands. These few species form the chief growth of the higher lands.

The swamp lands, with a total area of about 3,500 square miles, have a very characteristic and varied growth. Bordering these swamps are water and willow oaks, with the evergreen loblolly bay and sweet bay; farther in them are huge swamp chestnut oaks (*Quercus Michauxii* Nutt.), elms, maples, beech, holly and tall rosemary pines (*P. Taeda L.*). These lands constitute the *oak flats*, areas which are under water only during the wettest seasons of the year. They have usually a good soil and can be easily drained.

Where the water is deeper in the swamps and remains longer grow the cypress, sweet gum, black gum, tupelo and yellow poplar.

In the mud swamps along the larger streams there are, besides cypress and gums, ash, overcup oak, cottonwood, sycamore and hackberry. Mixed with the other swamps, but covering less area and occurring only on sandy or peaty soil, are white cedar swamps, or "juniper bays," as they are usually called. The tree growth in these is largely and often entirely juniper or white cedar (*Chamaecyparis spheroidea* Spach.) and white bay (*Magnolia glauca* L.). In the extreme eastern part of this section, in the immediate vicinity of the sea-coast, there is a characteristic arborescent flora of red cedars and live oaks, while along its southern limits the palmetto and American olive (*Olea americana* L.) give it a semi-tropical aspect. On the other hand, as the clay and loam of the hill country is neared, the oaks and hickories rapidly increase among the pines, making the transition to the hardwood uplands.

While this does not exhaust the list, even of the useful trees of this section, it includes those of greatest importance and widest distribution, and those most characteristic of the region. Those, however, which at present are of greatest economic importance are the pines, cypress, white cedar, ash and yellow poplar, and these only will be considered in detail, as the other forest trees of this section are not yet subject to the destructive agencies which prevent the extensive propagation and even threaten the future existence of at least one of the most valued of these trees.

NOMENCLATURE OF THE FOREST TREES.

The names of many trees occurring in the State are very much confused, some trees having several names applied to them in the same locality, while in other localities the same name is given to several distinct species. This is particularly true of the pines of the eastern section, so much so that they frequently cannot be distinguished at all by their local names. Names which are in very general use, and the use of which will prevent confusion, are those adopted by the United States Forestry Bureau. These names will be used throughout this report and are given in the following table along with the corresponding botanical terms and a list of the other names generally used in this State, with the region to which they are peculiar:

LONG-LEAF PINE (*Pinus palustris* Mill., *P. australis* Michx.) is known everywhere by this name, but *long-straw pine* is a term frequently substituted for it, the leaves of the pine after they have fallen being always called "straw." *Long-leaf old-field pine* is the name given to the young growth in fields, etc. *Pitch pine* is used in the north-eastern counties and by turpentine distillers. *Heart pine*, *North Carolina pine*, *Georgia pine* and *yellow pine* are lumbermen's names.

LOBLOLLY PINE (*P. Taeda* L.) is a name rarely heard in this State in the field, *short-leaf* or *short-straw pine* being the usual name. *Long-straw pine* is heard in the north-east, where this tree grows with *P. echinata* (the short-leaf pine), and *rosemary pine* is used along the Cape Fear river. *Slash pine, swamp pine* and *old-field pine* are names frequently given to it. *Sap pine, North Carolina pine* and *North Carolina sap pine* are names in use among lumbermen.

SHORT–LEAF PINE (*P. echinata* Mill.).—*Short-leaf pine* and *yellow pine* are names given it in the middle and western sections of the State, and it is there also the *old-field pine.* It is *spruce pine* in eastern and south-eastern counties and is known among mill men as *North Carolina* and *yellow pine.*

SAVANNA PINE (*P. serotina* Michx.) is also called *short-leaf*, and other names for it are *old-field pine, bastard short-leaf, swamp* and *pocosin pine.* This pine is seldom recognized as distinct from the loblolly. Its most frequent designation where so distinguished is *pocosin pine,* from its growing in flat, marshy land; the flat, undrained lands, usually at the heads of streams, being called "pocosins." These pocosins are covered with a low growth of gums, this pine, and an undergrowth of gallberry bushes, huckleberries and andromedas, while in places there is more or less coarse, densely stooled grass and sedges. This land often appears to be on the point of becoming savanna land, should the drainage become more thorough or its surface be raised by an accumulating peat. The common names for the other trees of this region, which are being discussed as being at present of considerable economic importance, are widely known and merely deserve mention: *Cypress* (*Taxodium distichum* Rich.); *yellow poplar* (*Liriodendron tulipifera* L.); *white cedar* (*Chamaecyparis spheroidea* Spach.), often called *juniper,* a name that is also applied to a small shrub farther north. Although three species of *ash* occur no distinction is made between them, each being called simply ash. These three species are the *water ash* (*Fraxinus platycarpa* Michx.), *white ash* (*F. Americana* L.) and *red ash* (*F. pubescens* Lam.). The first of these is a small tree confined in this State to swamps in the extreme eastern and southern parts. The other two are larger trees and occur in all parts of the State, either in swamps, along streams or in moist, cool places.

ORIGINAL DISTRIBUTION OF THE PINES.

The distribution of the pines and the respective area occupied by each in this State has changed a great deal since the first exploration of the country.

LONG-LEAF PINE (*P. palustris* Mill.).—The distribution of no tree has been more affected than that of the *long-leaf pine* by the transformation from a wilderness to a civilized country. The long-leaf pine formerly extended over the entire area under consideration, growing upon the drier portion of the sand. In the southern and south-eastern counties it formed a forest of pine, unmixed with other trees, but in the northern and western counties it was confined to the sandy or gravelly drift along the higher and drier ridges; here intermixed with short-leaf pine and scattering oaks, while poplar and loblolly pine occupied the lowlands.

Early in the last century the production of tar and turpentine was a profitable industry north of Albemarle sound, the commodities being taken to Norfolk or Nansemond, Va., for market.* The crude turpentine was shipped to England and there distilled. The largest bodies of pine which then yielded turpentine were the one on "Sandy Ridge," lying to the north of Edenton, and another east of Chowan river, in Gates county, and extending north into Nansemond county, Va. Before 1850 these had ceased to be of economic consideration, such trees as had withstood the fires and wind having been converted largely into building material. Now only isolated trees are to be seen here, scattered among black-jacks on the highest land. That they ever occupied much of the land might be questioned but for the tar-kiln mounds with which these counties are studded, the land having now a heavy growth of loblolly pine, and the mounds even bearing trees of this latter species two or three feet in diameter.

Southward these pines occurred only scattered over the high, sandy land lying between Albemarle sound and Washington. Now a tree of this species is rarely seen here. Between Washington and Newbern on a high sand ridge, with an area of 35,000 acres, was the finest body of pine in the Pamlico peninsula, but there is now very little merchantable timber of this kind left on it. West of this body it occurred in Beaufort, Craven and Pitt counties, only thinly dispersed among the loblolly pines as far as Kinston in Lenoir county, where on a suitable soil it again became the dominant forest tree, extending west as far as Enfield, and nearly to Raleigh. On the maritime sand hills just within the sounds there was a narrow belt in Currituck county, and in Carteret a wider belt in the middle of the county, lying north and south, parallel to the coast. In Currituck it is now confined to the southern promontory which projects into Albemarle sound, and in Carteret there are only several million feet of mill timber on the sand ridges opposite Bogue sound. From Carteret southward there was some uniformity as to its manner of occurrence. It occupied a belt from two to twenty miles wide immediately on the coast; beyond that lay a poorly drained basin of variable width and broken contiguity, embracing oak flats and gum and cypress swamps. The long-leaf pine re-appeared west of this and extended in an unmixed forest, broken only by river swamp, streams and occasional "juniper bays," to its western limits at Cary to ten miles west of Troy, and to Lilesville in Anson county. It is in this stretch of country that the largest areas lie which are either partially or completely denuded of all valuable tree growth and where a future growth is being entirely kept down by the systematic burnings to which those lands are subjected.

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*Wm. Byrd, Westover MS., Petersburg, Va., 1841, p. 27. (This manuscript was written in 1729).

South of North Carolina the long-leaf pine extends through Eastern South Carolina and Georgia, Southern Alabama and Mississippi, and west of the Mississippi river it re-appears in the sandy uplands of the valleys of the Red and Sabine rivers in Louisiana and eastern Texas, where it reaches its greatest development.

The quality of the wood of this pine varies considerably with the character of the soil on which it grows. Where the humus covering on the soil is thin, and the sand very deep, the tree has a coarser grain and a larger proportion of sap than where there is more organic matter in the soil, and it is not so highly silicious. The stocks with the coarser grain and larger amount of sap wood are distinguished as *pitch pine*, those with the finer grain and less sap wood as *heart* or *yellow pine*. The *pitch pine* yields turpentine more abundantly, can be worked for a longer time, and is less injured by repeated boxing and chipping. It is the more abundant in Onslow and Brunswick counties near the sea-coast, and on the highest sand hills of northern Bladen, Sampson and Cumberland counties. The *yellow pine*, containing mostly heart wood, makes the finer lumber and is the variety sought for by lumbermen.

LOBLOLLY PINE (*P. Taeda* L.) was originally confined to the lower and moister land, especially where it was loamy or slightly clayey, over the entire coastal plain region and westward beyond it about forty miles. While its limits have not materially changed it has increased its acreage, occupying now some of the higher and more sandy land, especially tracts which have once been under cultivation and much of the moister soil once completely or partially occupied by the long-leaf pine. Some original loblolly land which had a clayey or gravelly soil has been occupied by a heterogeneous growth of oaks, the white, post and black oaks and the black-jack being those that form the greater portion of the hardwood growth. As in the case of the long-leaf pine, the quality of the wood of the loblolly pine varies considerably with the different kinds of soil upon which it grows, and these variations in the wood and habit of the tree have given rise to the use of different local names which are applied by many persons throughout this region to what are considered by them different varieties of the "short-leaf pine," as the loblolly is commonly called. They are all, however, the same species (the loblolly pine) and their differences in quality of wood and appearance are due simply to dissimilarity of soil and other conditions which surround their growth. The principal kinds to which local names have been given are the following:

(1). The *rosemary pine* has a fine-grained (or sometimes coarse) wood, with a thin sap. It grows along the borders of deep swamps, or on mounds and hummocks within them, which are usually flooded during winter and spring. It grows with gums, cypress and ash, and is here the largest of the native pines, frequently attaining a diameter of 5 feet and a height of 130 to 140 feet, with a clear trunk of 80 to 90 feet. It has a bright brown bark broken into large, smooth, rectangular plates. It is found from

Virginia southward, the best developed trees recently observed being found on the Cape Fear river and its tributaries. South of the Cape Fear river they are not common. Some of these trees show on being cut that they are over 400 years old.

(2). The *swamp* or *slash pine*, which is the most frequent form of the loblolly, has a coarse grain, with the sap wood occupying half or even more of the diameter. The tree is smaller and the wood not so highly valued as that of the preceding, and is also said to decay more rapidly. It is most common on the moist or wet lands north of the Neuse river, where it forms a compact forest; and through this region and in the adjacent parts of Virginia it is the chief lumber tree.

(3). The *old-field pine* is a growth of the loblolly pine which is often looked upon in the south-eastern counties as a tree distinct from each of the preceding. It is, however, only a vigorous, exceedingly coarse-grained loblolly pine, which, having grown very fast, has only a small proportion of heart, logs 2 to 2½ feet in diameter rarely having one-fourth of their diameter heart. Of this open-grained wood both heart and sap decay rapidly on exposure to the weather unless painted or otherwise protected. But it is now being used very largely for indoor work, for which it is well adapted.

SHORT-LEAF PINE (*Pinus echinata* Mill.) is found mixed with hardwoods on all the dark, gravelly loam of the uplands and is there the chief lumber pine. In the eastern counties it was originally only scatteringly distributed, even in those adjacent to Albemarle and Pamlico sounds, where it was most abundant. From here it has been largely removed. South of Neuse river it was a rare tree, being found in small clumps interspersed among the long-leaf pines where the soil was inclined to be a dry or gravelly loam. Some trees on fertile soils become very large and have been removed for "tun timber." The wood of these larger trees is only a little coarser than that of the long-leaf pine; it is much lighter, though, and more brittle. On the sandy soil of the coastal plain region it does not abundantly reproduce itself, and young trees are uncommon, but on the uplands it is rapidly increasing and its young growth promises to play an extensive part in the future development of this section. As it has the smallest cone and shortest leaf of any pine in the eastern portion of the State it can be readily distinguished. This pine has a wide distribution, extending north to Massachusetts and west to Kansas and eastern Texas. It always occurs mixed with hardwoods or other pines.

SAVANNA PINE cannot readily be distinguished from the loblolly in young trees, but mature trees are easily separated. It is a medium-sized tree, whose trunk holds its size well, being covered with limbs and knots for the upper two-thirds of its height. The leaves are similar to those of the loblolly, but the bark is a darker brown and smoother. It is always covered with cones, which remain on for several seasons. These are shorter than the cones of the loblolly, conical, and usually have the scales closely oppressed. This species is of but little commercial value and is rarely used for the reason that the wood is coarse-grained and gummy, with a large proportion of sap wood, and the trees are frequently unsound. The savanna pine has been but slightly affected by the causes which have operated to increase or diminish the distribution of the other pines. Being sawn for lumber only by accident, and growing only on a few kinds of soil, and such soils as are unfit for agricultural purposes, the amount of it standing to-day is practically the same as formerly.

FORESTS AND FOREST REGIONS IN EASTERN NORTH CAROLINA.

The following descriptions of the counties of the coastal plain region show, in a general way, not only the quantity of merchantable timber now standing in the several counties, but also, when such figures were obtainable, the areas and character of such lands as have been lumbered. They also show the condition in which these lands were left after being cut over, and the kind of young growth which is succeeding the one removed, whether it be the same or a different kind, and give such tracts as have been burnt over after lumbering, on which the tender young growth and trees which might serve for seed trees have been partially or completely destroyed.

The acreage of the various kinds of timber, excepting the long-leaf pine, is prepared from information furnished by county officials, lumbermen and residents familiar with the lands of their respective sections. The amount of standing long-leaf pine is an estimate based on the number of barrels of rosin produced in each county, the unboxed round pine and the abandoned orchard also being taken into consideration. These figures were corrected in some instances by the estimates obtained direct from the acreage of standing pine, the figures for such acreage coming from county records which show the character of the timbered lands of the townships. Besides this a thorough personal examination was made of the condition of the timbered lands in different sections of each county.

The counties, beginning with those that lie nearest to the coast and proceeding inland, have been grouped according to the character of their dominant economic timbers as they stand at the present time.

THE SEABOARD REGION lies along the coast or but a short distance inland. It has an elevation of from 10 to 100 feet above the sea-level. Its average altitude, however, is not over 30 feet, and the only points which attain an elevation above 70 feet are a line of drifting sand dunes along the north-east coast, which in places are over 100 feet high.* The counties included in this region are Columbus, Brunswick, Pender, Onslow, Duplin, Carteret, Jones, Craven, Pamlico, Beaufort, Hyde, Dare, Tyrrell, Washington, Chowan, Perquimans, Pasquotank, Camden and Currituck. These counties have loblolly pine as the dominant forest tree, though in the most southern ones there is considerable long-leaf pine, and there are numerous swamps with a growth of sweet and black gums, cypress and white cedar.

THE INLAND LOBLOLLY PINE REGION, which lies along the Neuse river and north of it, farther inland than the seaboard, embraces the counties of Gates, Hertford, Bertie, Martin, Pitt, Greene, Edgecombe, Wilson, Lenoir, Wayne and Johnston. Their elevation is slightly higher than that of the seaboard counties, and will average between 100 and 150 feet, being higher toward their western borders. Their upland growth is nearly all loblolly pine, except that in Lenoir, Wayne and Johnston counties there is considerable long-leaf pine. There are few swamps except along the streams.

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*Geology of North Carolina, W. C. Kerr, Vol. I, 1875, pp. 13-19.

THE PINE-BARREN REGIONS.—The counties containing the larger portion of the pine-barren areas are New Hanover, Sampson, Bladen, Robeson, Cumberland, Harnett, Richmond and Moore. These lie south of the Neuse river and just west of the southern seaboard, excepting New Hanover, which is situated at the mouth of the Cape Fear river. The altitude of these counties varies between about the same limits which were given for the inland loblolly pine counties. Long-leaf pine or the sand black-jack, which has largely replaced it, is the characteristic growth of these counties.

THE TRANSITION REGION.—Nash, Halifax and Northampton counties form a tier of counties which are transitional between the loblolly uplands and the hardwood hills. These in their western portions have an altitude of from 200 to 400 feet, while their eastern portions lie at a lower level. They have no swamps except narrow strips of alluvium lowlands along the streams, which are subject to overflow. Montgomery, Chatham and Wake form another tier of transitional counties. They lie partly in the long-leaf pine belt and partly in the hardwood hill country. The western portions of these counties reach an altitude varying from 450 to 700 feet; but along the streams and in the more easterly portions their altitude is considerably less.

THE SEABOARD REGION.

BRUNSWICK COUNTY has in its western part 4,000 acres of white cedar land, most of it located along Juniper creek, Green swamp and its ramifications, and 20,000 acres of excellent cypress and loblolly pine lands which have never been lumbered. The lumbered districts lie in the northern part of the county along the W. C. & A. R. R. and in the northern arms of the Green swamp, which are tributary to the Cape Fear river. Much timber has also been rafted out by way of Waccamaw river from the extreme western part of the county to the mills at Georgetown, S. C. The oak lands bordering the numerous swamps are equal in area to the cypress lands and are destined to become very valuable. The entire swamp area is 166,000 acres, one-half of which is gum swamps and cane brakes. The cutting has been done gradually in these swamps and the young growth is in a fair condition. The long-leaf pine lands lie in the southern and central parts of the county and consist mostly of turpentine orchards either still being worked or now abandoned. There are in this county 130,000,000 feet of standing long-leaf pine.

COLUMBUS COUNTY has in its southern and eastern parts, along Waccamaw river and the lake swamp and in Green bay, some very fine cypress. These bodies have in part been lumbered. In White and Brown marshes and in the western section of the county, along Lumber river and Big swamp, there are large tracts of unlumbered cypress lands. The total area of cypress in the county is about 32,000 acres. In Green bay swamp, from which large quantities of white cedar have already been taken, there still remains a great deal more. There are 60,000 acres of swamp lands in the county. On the level pine flats there are between ten and twenty thousand acres of loblolly pine, largely second growth, very little of which has ever been cut. The long-leaf pine lands lying in the central and northern portions of the county have 145,000,000 feet of merchantable pine standing on them.

DUPLIN COUNTY contains about 12,000 acres of cypress swamp along the North East river and its tributaries. Adjacent to the streams much of the best timber has been culled or picked over. The remaining merchantable cypress lies principally along North East river, Back swamp, Goshen, Lockwood and Cypress pocosins. There are excellent water oak, willow oak and swamp chestnut oak in the flats bordering the above-mentioned swamps and Angola bay. There is some ash and yellow poplar, but the wood of neither tree is here of a superior quality. Over one-half of the swamp area, which amounts to about 38,000 acres, is covered with compact forests of black and sweet gum and tupelo. The loblolly pine, which is largely second growth, occupies about 50,000 acres. There is still some rosemary pine on the more fertile lands around the smaller swamps. The quantity of standing long-leaf pine is not large, only 68,000,000 feet. This county and Pender have furnished a great deal of timber for the Wilmington mills.

PENDER COUNTY.—Several of the swamps of this county are continuations of the swamps of Duplin which lie along the North East river. Besides these there is Holly Shelter swamp, a large swamp in the eastern section of the county and extending into Onslow county. There is altogether 15,000 acres of cypress land, one-third of which has been culled, the largest and finest trees having been cut out to make drawn shingles from them. The finest cypress is located in Holly Shelter and the North East river swamp. Angola bay, lying partly in this county and partly in Duplin, covers 120,000 acres. Through this swamp there are extensive areas which have a very poor, sandy soil and are covered only with reeds and brambles and the savanna pine. There is a considerable area of water oak and swamp white oak flats bordering the swamps. The swamp area is about 160,000 acres. The loblolly is largely second growth and occupies the flat pine lands of the middle section. There are 90,000,000 feet of long-leaf pine standing in the county.

ONSLOW COUNTY.—Although this county has a very large swamp area, over 100,000 acres being swamp, only about 4,000 acres of it, consisting of narrow strips along the streams, can be called cypress land. Both White Oak swamp and Holly Shelter swamp are fringed with a broad belt of swamp white oak and water oak flats. At least one-third of these swamps is "gladey," being covered with gallberry bushes, or cane brakes and a scrubby growth of savanna pines, and has a soil of sand that is exceedingly barren of fertility and forests. There are no extensive areas of heavily timbered gum swamp in the county. Loblolly lands, covering 58,000 acres, occupy the greater part of the center of the county, while the long-leaf pine lies chiefly in the north-western part. There are 60,000,000 feet of the latter standing. The sand hills adjacent to the coast, formerly covered with long-leaf pine, are now almost denuded. In parts of the county near the coast there is a scattering growth of red cedars. They are, indeed, in this and Carteret counties more abundant than in any other portions of the State, but are generally found in considerable numbers on all the "banks" and islands skirting the coast. White cedar occurs in several "bays" in the western section of the county, and forms the growth of a "bay" of considerable size near the source of White

Oak river. The loblolly and cypress have been removed to a large extent from the territory drained by White Oak river. Lumbering has only lately begun, however, in other parts of the county.

CARTERET COUNTY.—There is now found in Carteret county scarcely any cypress suitable for mill purposes. The loblolly pine area is about 30,000 acres, over one-half of which have been lumbered. In southern Carteret, near the coast, there are 20,000,000 feet of long-leaf pine, all consisting of timber standing in abandoned orchards. In the eastern section of the county there is an open pocosin of 80,000 acres, bordered with oak flats, but farther in only poorly timbered with savanna pine or in places entirely open.

CRAVEN COUNTY.—Although extensive lumbering has been carried on in this county for over half a century it has large tracts of second growth of loblolly forest which have never been cut into. The long-leaf pine was first removed and was rapidly replaced by the loblolly pine, except on the high, sandy lands lying north of the Neuse river. Most of the lumber now manufactured in the county is from this latter pine, although for some mills the savanna pine furnishes a great many logs. There are nearly 200,000 acres of swamp in the county, the Dover swamp, lying in the south-western section, having an area of over 120,000 acres. This swamp is sandy, and in the interior is covered with an open growth of the savanna pine and occasional cane brakes. It has been partially lumbered. The other swamps are fringed with swamp chestnut, oak or water oak flats, which have never been cut into. Besides the swamp lands there is a great deal of loblolly pine land south of the Neuse, which has been more or less cut over. North of the Neuse the loblolly pine lands are in about the same condition as on the southern side. There are in the county probably 38,000 acres of unlumbered loblolly pine land. The supply of cypress and ash in the river swamps is nearly exhausted, Swift creek and Trent river being now the principal sources of supply.

JONES COUNTY lies between Craven and Onslow counties and is penetrated by some of the largest swamps in this region. Dover swamp lies in the northern part of Jones, and White Oak swamp covers a large part of the territory south of the Trent, which flows through the center of the county and with its tributaries drains nearly its entire area. In the extreme eastern part lies the great pocosin of which Catfish lake is the center. This pocosin, extending eastward, occupies under different names much of the territory of southern Craven. All of these swamps in their interior have considerable tracts of land entirely untimbered, or covered with scattering savanna pines, small maples and gums, and have a large, unproductive soil of silt. They are, for the most part, bordered by extensive oak flats, though around White Oak swamp there are still large quantities of yellow poplar, ash and cypress. The cypress along the Trent river has been largely removed. The entire swamp area in the county approximates 125,000 acres. Excepting some narrow strips of sand hills lying parallel to the Trent river, which have a few million feet of long-leaf pine on them, the rest of the county consists of flat, loblolly pine lands, which have been largely cut over. There are between 25,000 and 30,000 acres, mostly lying in the western part of the county, yet in a virgin state. This county yearly supplies several million feet of logs for the mills at Newbern.

PAMLICO COUNTY has 3,000 acres of white cedar swamp, partly lumbered, lying near Vandemere and along the western edge of Big Gum swamp in the northern part of the county. There are 7,000 acres of cypress swamp, over half of which are lumbered. This cypress swamp lies near the mouth of Bay river and in Gum swamp. The remaining swamp area is heavily timbered with yellow poplar, gums, chestnut oaks and water oaks. The soil of these swamps, though inclined to be peaty, is exceedingly fertile. The loblolly formerly covered all the rest of the county with the exception of a narrow strip of high, sandy land in the north-western section, which, in the character of its soil and the kinds of trees which grew on it, approached the pine barrens. There is now, however, no merchantable long-leaf pine in the county and not more than 10,000 acres of loblolly pine suitable for milling purposes. The central part of Big Gum swamp is open, covered with scattered savanna pines and an undergrowth of gallberries, huckleberries, brambles, etc.

BEAUFORT COUNTY.—There is some cypress along Chocowinity, Blount and the other streams of the county, but the supply is rapidly being exhausted. The loblolly pine, which had an original area of over 100,000 acres, has been largely removed except in the north-eastern section. Much of the best oak in the county has been converted into staves for the West Indies trade.

THE PAMLICO PENINSULA, consisting of the counties of Hyde, Dare, Tyrrell and Washington, is largely swamp, having over 1,000,000 acres of swamp in it. The uplands consist of narrow strips surrounding the swamp and land which has been drained around lakes Phelps, Pungo and Mattamuskeet. Around the eastern edge of the swamp and enclosing the sound is a narrow strip of treeless sand dunes. Much of the soil of the swamp, especially in Dare, Hyde and Tyrrell, is peaty and covered with a growth of white cedar and bays. There is estimated to be about 40,000 acres of white cedar now in the swamp. The cypress acreage is not near so large as formerly, but there is still a large amount standing. The largest bodies lie in Tyrrell and Washington counties. The cypress lands, too, are the most fertile, and have to a large extent been drained and put under cultivation. Along the outer edges of the swamps are oak flats, which in Hyde are very extensive.

The northern portions of Dare, Tyrrell and Washington, bordering on the sound, have a growth largely of loblolly pine with some oak lowlands. The standing pine has been removed from over half of this area, which is about 100,000 acres. In western Dare there are also extensive tracts of pine lands which extend into Beaufort county. Much of the swamp in Washington and Tyrrell counties is thinly timbered with the savanna pine. There is a great deal of soft maple and yellow poplar scattered through the swamp, and in places on the most fertile soils are considerable quantities of hickory, both the shag-bark and white-heart hickory. Lumbering has been one of the leading industries of these counties for a great many years, the numerous canals and streams which penetrate the region affording great facilities for removing timber.

THE COUNTIES NORTH OF ALBEMARLE SOUND are so similar in the character of their forests and soil, and are so closely connected with each other, that they can best be described as one body. Five counties occupy this territory, *Chowan*, *Perquimans*, *Pasquotank*, *Camden* and *Currituck*, lying from west to east in the order named. All except Chowan are penetrated in the northern parts by the Dismal swamp, or arms of it which lie on the boundary between this State and Virginia. About 65,000 acres of Dismal swamp area lie in these counties. Although the swamp varies a great deal in character of soil, most of it is peaty and was formerly covered by a heavy growth of white cedar. All of this cedar swamp has been lumbered, except about 8,000 acres, and about 8,000 acres have been repeatedly burnt over, effectually destroying all trees, and in places burning out the soil to a great depth. There were some narrow tracts of cypress in these swamps, and also in the swamps along the streams, but the cypress, like the white cedar, has been largely removed. These streams rise in the Dismal swamp and flow southward, cutting this territory into long divisions, forming the natural boundaries of the counties and convenient water-ways for removing timber along them. Oak was at one time abundant, but the finest has been cut out for staves and to supply the Norfolk navy yards. The finest pine also was removed many years ago for use in the navy yards.

The construction of two canals, the numerous natural waterways, and later a railroad crossing these at right angles, associated with the nearness of Norfolk and the facilities offered there for the shipment and marketing of lumber, had, as early as 1850, built up a large trade in timber and lumber from these counties. The lumber which is now manufactured is almost entirely from the loblolly pine. During the past decade there has been shipped from this section in the log over 800,000,000 feet board measure, while nearly as much more has been sawn by local mills; but such is the wonderful recuperative power of the loblolly pine forests on a suitable soil that now there remains not less than 25,000 acres of merchantable pine. The production of timber in these counties is, however, not one-half of what it was ten years ago, and sooner or later the annual output will be reduced to the increase in the forest by the growth each year.

These regions around the Dismal swamp were about the southern limits of the economic distribution of the holly, the trees reaching here a large size. Large quantities of holly, dogwood and soft maple have also been removed, but there is still a great deal left. Some sandy ridges near the middle of these counties were once covered with long-leaf pine, but there are scarcely any trees of it left now. The area of these counties is 750,000 acres, over 95,000 of which are in swamps. The savanna pine is found at intervals through the swamps, and extends into Southern Virginia, as does the tupelo gum. Some of the cypress lands are largely timbered with gums. The soil, for the most part, is sand or a sandy loam, but in the Dismal swamp, where it is not peaty, it is usually composed of fine silt. The timber lands of these counties have, as a rule, been more thoroughly lumbered than any others in the State.

THE INLAND LOBLOLLY PINE REGION.

GATES COUNTY, like the region just described, lies on the Virginia line, and has the extreme eastern part lying in the Dismal swamp. The Chowan river, which forms the southern and western boundary of the county, has along its entire course a narrow swamp. There are 20,000 acres of white cedar lands in this swamp and several thousand acres in the Dismal swamp which are untimbered. The little cypress still standing in the county lies along Bennett's creek. Loblolly pine, which occupied the central and eastern parts of the county, growing on a sandy loam, has been removed, except between ten and twenty thousand acres which are in small tracts. In the western part of the county is a high sand ridge resembling the pine barrens. The long-leaf pine has been removed from this and an open growth of loblolly and short-leaf pine with black-jack beneath them has taken its place. In the extreme north-western portion there is a strip of bright-colored loam soil, timbered with a heavy growth of post, black and red oaks. Most of the timber cut from this county is transported to Virginia.

HERTFORD COUNTY is the first of a number of counties lying in the pine uplands which has no large swamps. The eastern and southern parts of the county have a sandy loam soil, in places silty and very compact, which was covered with a dense loblolly pine forest, now largely lumbered, through which were interspersed narrow strips of white and red oak lands. In the northern part of the county there is more oak and dogwood mingled with the pine.

There are about 25,000 acres of unlumbered loblolly pine land. The cypress, which is confined to the alluvial land along the streams, is more abundant along the Ahosky and Pottecasy than any other streams.

BERTIE COUNTY has a soil and growth similar to those of Hertford county, consisting for the most part of upland loblolly pine lands. In the southern part, however, it is skirted by the Roanoke river, which is bordered with a broad swamp still having large quantities of white and red oaks, gums, maple, cottonwood, hickory, sycamore and elms and some ash and cypress in it. There is also some cypress along Cashie and Roquest creeks. Although the timber yield of this county has been very large for a number of years there are now standing 65,000 acres of unlumbered loblolly pine. Early in this century Bertie county was known as the "pine forest," on account of the density and excellence of its forests of this tree.

MARTIN COUNTY lies south of Bertie on the opposite side of the Roanoke. Its soil is similar to that of the last described counties, but the Roanoke river swamp is less continuous, being confined to several bends in the river in the eastern part of the county. Along the river there are some narrow sand ridges, now covered with black-jacks and small post and red oaks. The remainder of the forest area is loblolly pine land, about two-thirds of which has been cut over. The county is the seat of extensive milling operations.

PITT COUNTY, being drained in the northern and eastern parts by the Tar river and Grindle creek, one of its largest tributaries, has for many years furnished large quantities of timber for the mills at Washington. Along all the streams are large stretches of cypress swamp and oak lands, the latter forming virgin forests and the former only partially lumbered. The loblolly pine near the larger streams has been extensively cut. In the southern and western sections the soil becomes more sandy, and the original growth, long-leaf pine, has been replaced by loblolly pine, mixed with a low growth of oaks. The loblolly has never been removed from this section.

GREENE COUNTY, which lies just south of Pitt, has in the northern parts a soil similar to that of the adjacent portion of Pitt, and is covered with similar forests. In the southern section the soil is more sandy and there are numerous sand hills, approaching the pine barrens, now nearly denuded of the long-leaf pine, which was once abundant, and largely covered with sand black-jacks. Along Contentnea creek and its numerous tributaries, which drain the entire county, are extensive tracts of cypress swamps. In the northern part of the county these swamps, which extend over into Pitt, have been but little lumbered; in the central portion, however, exploration has been carried farther. About one-half of the forest lands, or 30,000 acres, is still covered with merchantable loblolly pine.

EDGECOMBE AND WILSON COUNTIES lie west of those last described and have an average elevation of about 50 feet higher than that of these counties. Their soil is considerably drier and more sandy than that of the section to the east of them, being a sandy loam, which in places passes almost into sand. The long-leaf pine, which primarily occupied these lands, has been largely destroyed and a scattering growth of loblolly pine, with an undergrowth of low post and red oaks and dogwood or thickets of black-jack oak, have taken its place. There are along the streams occasional strips of cypress swamp which have not been lumbered and there is a considerable quantity of other swamp timber, sweet and black gums, tupelo, soft maple, and occasional overcup and chestnut oaks. Although over one-half of the area of these counties is under cultivation, there is still standing a considerable quantity of merchantable loblolly pine.

WAYNE, another of the loblolly pine counties, has in the section contiguous to Wilson county a soil and forest similar to those of Wilson, but south of the Neuse river, which flows through the centre of the county, there are extensive tracts of pine barrens, stripped of pine and covered with sand black-jack oak or completely denuded. Skirting the Neuse river and its tributaries are tracts of swampy alluvium, on which there are still merchantable gums and oaks, and in places cypress and ash. The loblolly pine (rosemary), which was once abundant along these lands, has for the most part been removed. There are several small white cedar "bays" at different places in the county. The loblolly pine, except that along the streams, is all second growth and forms open forests. About one-fifth of the wood land, or 30,000 acres, is loblolly pine fit for mill timber. When removed this loblolly pine is apt to be succeeded by small oaks. There are now standing in this county probably 30,000,000 feet of scattering long-leaf pine.

LENOIR COUNTY is situated on the Neuse just below Wayne, and its swamp lands along the Neuse are of the same character and in a similar condition. The extreme southern and western parts of the county are very sandy, and in places on the ridges there are important bodies of long-leaf pine, or black-jack oak, which in places has replaced it, while between the ridges there lie very narrow alluvial or peaty bottoms covered with a growth of swamp timbers. Scattered through the county are plains, at times inundated, on which there is a growth of oaks, maples, elms and ash. The eastern section is flat loblolly pine land covered with a heavy growth, except near the river; but there are scattered through this loblolly pine forest small pocosins covered with savanna pines and a variety of shrubs. There are about 30,000 acres of loblolly pine and 30,000,000 feet of standing long-leaf pine in the county.

JOHNSTON COUNTY lies west of Wayne and is also drained by the Neuse. Along the river and its numerous tributaries there are the usual strips of swampy alluvium covered with swamp timbers. In the eastern and southern parts of the county the soil is a sandy loam, which becomes more loamy toward the north and west, and the surface in these sections is more rolling and hilly. The timber on this loam consists of long-leaf pine, mixed with oaks and loblolly pine, and in the southern section near the river there are quantities of valuable loblolly pine. There has been very little milling done in the county, but considerable timber has been rafted to mills down the river. The long-leaf pine is being very rapidly replaced by the loblolly pine, the amount of the former now standing being only about 160,000,000 feet.

THE PINE-BARREN REGION.

IN ROBESON COUNTY there is along the dark loam lands of the Lumber river 28,000 acres occupied exclusively by the loblolly pine. This pine is in all stages of growth, and is gradually taking the place of the long-leaf pine as the latter is being destroyed by forest fires or otherwise. Many of these tracts covered with loblolly pine appear, however, to have always been occupied by this tree which here forms, on soil sufficiently moist and loamy, small clumps of unmixed growth frequently 100 acres or more in extent. These trees are coarse-grained, largely of sap wood, and are from two to two and one-half feet in diameter. None of these have ever been cut for lumber. In Big swamp there is probably 5,000 acres of loblolly pine, which is largely of the *rosemary* variety, mixed with large gums and cypress trees. Only a part of this swamp has been lumbered. The area of the gum and cypress swamps is about 30,000 acres, lying in Big swamp and its tributary marshes, Flowers swamp and the other swamps along Lumber river. There has been very little lumbering done in them. There are no extensive oak flats in the county and little ash or poplar. On the long-leaf pine uplands, lying in the southern and northern sections of the county, there are 280,000,000 feet of merchantable timber. The pine lying immediately along the railroads has been to a large extent removed.

BLADEN COUNTY has about 12,000 acres of cypress land lying along Brown marsh, Big swamp, Cape Fear river, Colly and Turnbull creeks. About 4,000 acres have been more or less thoroughly lumbered; and there are about 3,500 acres of white cedar swamp, which have to a large extent been cut over, but were left in a fair condition. This latter lies in Big Juniper bay and various smaller bays on the north side of the Cape Fear. There are large tracts of untouched oak flats and gum swamps mostly in the southern and western parts of the county. Good ash, except in the smaller swamps, is becoming scarce. This county has a swamp area of about 55,000 acres. The loblolly pine, except along the swamps, is usually scattering. There cannot be less than 10,000 acres occupied by this pine, only the finest and largest trees having been removed. The long-leaf pine lands of Bladen have been very badly treated. On either side of the Cape Fear river there are extensive tracts of "pine barrens," on which this pine has been very largely destroyed, so that it is really waste land. But there is still about 308,000,000 feet of standing long-leaf pine, lying chiefly in the western and southern parts of the county.

NEW HANOVER COUNTY lies immediately on the coast, and consists largely of pine barrens. The long-leaf pine has been for the most part removed or destroyed. There are still, however, several million feet standing in different parts of the county. In the northern part along the North East river there is some swamp land timbered with gums and some oak. Smith's island, which lies at the southern extremity, is densely timbered with a growth of hardwoods, largely water and live oaks, interspersed with palmettos.

CUMBERLAND COUNTY, like the northern part of Bladen, lies largely in the sand-hill region and contains considerable areas of "pine barrens," from which the original long-leaf pine forests have been removed. In the eastern part of the county there is some white cedar along the streams or occupying small swamps, and along most of the deeper streams there is cypress. There are no extensive bodies of merchantable oak or loblolly pine to be found. In the eastern part of the county the long-leaf pine has been largely cut out, but west of Fayetteville it forms extensive forests, extending nearly to the Moore county line; and there are probably 310,000,000 feet of standing long-leaf pine in this region.

HARNETT COUNTY is situated north of Cumberland, and that part of it lying south of the Cape Fear river, which divides the county into northern and southern halves, is a continuation of the rolling sand-hill country with its pine barrens of Cumberland county. The larger part of these pine lands is in an exceedingly bad condition, having been burnt over until there are extensive tracts entirely denuded of all tree growth. There is very little cypress to be found in the county. North of the Cape Fear river the country merges into the dark loam uplands covered with a young growth of oaks, dogwood and loblolly pine, which are replacing the long-leaf pine. There is only about 200,000,000 feet of long-leaf pine now standing in the county. Harnett county furnishes some timber for the Wilmington market, last year it having been estimated that about 1,500,000 feet, board measure, of long-leaf pine timber was rafted down the Cape Fear river.

SAMPSON COUNTY.—The oak lands of Sampson lie in the northern part of the county and are covered with a growth of young white and post oaks. There are no large bodies of water or chestnut oak flats. The cypress and gum swamps lie in narrow strips along Black river and Big and Little Cohary creeks. The unlumbered cypress lands cover about 3,800 acres, and about an equal area has been cut over to obtain timber for the Wilmington market. The long-leaf pine lies chiefly in the southern and central parts of the county. The standing pine amounts to about 330,000,000 feet. The loblolly pine, largely second growth, is scattered through all sections of the county and occupies about 35,000 acres. This county has for many years furnished a large part of the timber that is carried to Wilmington.

RICHMOND COUNTY.—The larger portion of this county may be described as being typical sand-hill country, the surface being undulating and even hilly, and the soil sandy; the sand often being many feet deep. In the extreme western part there is along the Pee Dee a narrow strip of alluvial swamp, heavily timbered with red, overcup and chestnut oaks, red maple and hickory. In the eastern part of the county there are white cedar, gums and cypress of inferior quality along the streams. The long-leaf pine which covers the remainder of the county has, over the larger areas, been removed when adjacent to the railroads. Lumbering is, however, largely carried on in the northern part of the county at the present time, and extensive bodies of timber still remain there and in the eastern section. There remains probably 220,000,000 feet of standing long-leaf pine.

MOORE COUNTY lies north of Richmond and has in the southern part, along the sand hills, a similar soil and topography. This section, embracing the southern two-thirds of the county, is covered with long-leaf pine and is the seat of the largest long-leaf pine industry in the State at the present time. In the middle portion of the county, where the soil is more loamy, there is considerable post oak and small hickories mixed in with the pine along the hill-sides and yellow poplars and a few loblolly pines along the lowlands. The northern third of the county has a loamy soil covered with a growth of hardwoods mixed with long-leaf and short-leaf pines. Although extensive lumbering operations have been carried on in these pineries for the past fifteen years, so that all timber near existing lines of railroad has been removed, there are probably 320,000,000 feet of long-leaf pine still standing in the county. The long-leaf pine is succeeded in this county, as is the case in Richmond, by sand black-jack oaks. In the very sandy parts of the county there is only a little loblolly pine, with small cypress trees and some white cedar scattered along the streams.

THE TRANSITION REGION.

NORTHAMPTON COUNTY is situated on the boundary between the loblolly pine uplands and the hardwood hills which cross the western third of the county. The loblolly is mixed in places with scattered short-leaf pine, and is, except along the swamps and streams, very largely a second growth. It has never been lumbered. The southern and western boundary of the county is the Roanoke river, and along its entire course there is a strip of alluvial swamp from one to three miles wide, covered where there have been no clearings made with a heavy growth of trees similar to that along the same river in Bertie county (p. 20).

HALIFAX COUNTY.—The eastern half of Halifax county, like the greater part of Northampton, is a fairly level region, with an average elevation of but little more than 100 feet above sea-level. The soil is generally a sandy loam, and the forests of this region consist mainly of loblolly pine with the short-leaf pine, post oak, spanish and white oak interspersed. On the northern boundary of the county along the Roanoke river lowlands, which are of less extent on this side of the river than on the northern side in Northampton county, are at intervals forests of black gum, sweet gum, red maple, elm, red oak, ash, sycamore, hackberry, and other deciduous trees. Occasionally one finds on portions of these fertile lowlands, the cultivation of which ceased some fifty years ago, vigorous but scattering black walnut trees nearly 2 feet in diameter and more than 50 feet high. Beech creek, likewise, with its larger affluents, Marsh and Beaver Dam creeks, have along their courses some ash, cypress, gums and tupelo, and these streams are bordered in places with extensive flats of scarlet, chestnut, overcup and willow oaks. The western half of the county is quite hilly, as are also the western portions of Northampton and Nash counties. The soil, while sandy, gravelly and pebbly in places, is in general much more clayey than that of the eastern section. The forests of this western half of the county are mostly oaks, hickories and other hardwood trees, with a few scattering short-leaf pines.

NASH COUNTY has a soil and topography much resembling those of eastern Wake, being a rolling country, hilly along the larger streams and having a light loam soil. The growth, also, is like that of Wake, consisting of scattered long-leaf pines, about 20,000,000 feet, board measure, standing, which is rapidly being replaced by loblolly, or on close soils by oaks, dogwood and hickories. The long-leaf pine extends west to the clay hills; on which the hardwoods of the uplands are mixed with short-leaved pines. There is more loblolly pine here than in Wake, both original growth and second growth. There has been very little lumbering done in the county except immediately along the lines of the railroads.

MONTGOMERY COUNTY, lying west of Moore, has in the eastern part, on a loam soil, a heavy growth of long-leaf pine which has never been lumbered. This growth toward the middle of the county is mixed with short-leaf pine and hardwoods, and there the hardwood uplands begin. This is the finest body of pine for lumber now in the State, having been worked for turpentine for only four or five years. There are 338,000,000 feet of long-leaf pine in the county and about 40,000,000 feet of short-leaf. There are some extensive bodies of hardwoods in the Uwharrie mountains in the western section.

CHATHAM COUNTY now has an inconsiderable amount of long-leaf pine in the extreme south-eastern section. Its place has been taken as it was removed by a heterogeneous growth of oaks and the short-leaf pine. In the middle part of the county there are along the ridges short-leaf pines and hardwoods, while the lowlands along the Haw and the Deep rivers are timbered in most places with oaks, maple and loblolly pine.

WAKE COUNTY has in the eastern part considerable long-leaf pine still standing, mixed with a young and vigorous growth of oaks and dogwood. The soil is for the most part a reddish loam, interspersed with sandy ridges, on which the long-leaf pine, where it has not been replaced by black-jacks, is more abundant than on the loam.' There are 30,000,000 feet of this pine standing. East of the center of the county the short-leaf pine appears, and from there westward it is the commonest old-field pine. There is a very large acreage of both second growth short-leaf and loblolly pines in the county and probably 60,000,000 feet of their original growth standing in the eastern section. To the north and west of Raleigh the surface is more broken and the oak growth more abundant, except along the gravelly ridges, where there is short-leaf pine. West of Wake the loblolly pine becomes less frequent.

EXISTING SUPPLY OF TIMBER IN EASTERN NORTH CAROLINA.

In conclusion, it can be said that certain kinds of timber, both useful and abundant, are as yet of little commercial importance in most parts of the coastal plain region. Such are water, willow, overcup and chestnut oaks, sweet and black gums, soft maple and sycamore. The supply of some other kinds of timber, such as ash and holly, has been nearly exhausted.

There are still large quantities of *cypress* standing in some counties, while in others the supply has been almost exhausted. This tree is of very slow growth and shows little tendency to reproduce itself abundantly, the regrowth after it has been removed generally being sweet and black gums. The soil of cypress swamps is usually one of the best of swamp soils and when drained is very productive; so these swamps are being put under cultivation. Considerable areas have already been reclaimed for agricultural purposes, and a great deal more is to be thus reclaimed in the near future. It is evident from this that in this State there will never be any general second growth of cypress to take the place of that which is now being removed.

White cedar, which usually occurs with white bays in small swamps or in clumps in other swamps, flourishes only on a peaty or very sandy soil which is largely mixed with organic matter. These soils are unfit for agricultural purposes and their fertility is easily destroyed by fire during very dry seasons, especially where the dried *debris* resulting from logging fills the woods. Unless these swamps are burnt out a growth of the same species is most likely to replace the white cedar after lumbering, but in the event of a fire the white bay (*Magnolia glauca* L.) will succeed and usually retain possession. Although white cedar is very valuable, grows rapidly, and there is only a comparatively small amount in the Eastern United States, these swamps are from carelessness frequently burnt and the chance of a regrowth thus destroyed.

The *loblolly pine,* now generally recognized as a valuable lumber tree, is the dominant pine over a large area, and has been removed from only a relatively small part of the territory it occupied. It is a tree of rapid growth which seeds abundantly and usually follows itself after lumbering. Oak occasionally replaces it as the hardwood uplands are neared. However, on account of the destruction of a great part of the young growth, these second growth forests are never as dense as they should be. This produces less timber to the acre and is the cause of many deformities, as knotty, crooked and short-stemmed stocks. The loblolly pine is also taking the place of the long-leaf pine in the forest on moist soils, and on drier soils when the latter have been under cultivation. The standing merchantable loblolly pine can be said to cover about 1,150,000 acres in the eastern part of the State. Allowing a cut of 4,000 feet, board measure, to the acre, this will make 4,600,000,000 feet of standing loblolly pine. At the present rate of cutting, 290,000,000 feet, board measure, having been reported as cut during 1893, this would last fifteen years. The final amount cut will, however, be much larger than this, since in the meanwhile there will be a constant increase each year in the amount of young growth available for milling purposes and a considerable increase in the size of the merchantable pine now standing. The entire acreage of loblolly pine land, including the lumbered areas with second growth on them, the unlumbered and lands where it is taking the place of the long-leaf pine, is considerably over 4,000,000 acres.

There are possibly 300,000,000 feet of the *savanna pine* in pocosins and around the edges of swamps and nearly as much *short-leaf pine* situated in the counties bordering the oak uplands. Most of this will be lumbered along with the loblolly pine.

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The total amount of merchantable *long-leaf pine* now standing in the State is about 3,103,000,000 feet. The estimate of Mr. Kidder, of Wilmington, N. C., prepared for the United States Census Department, fixes the amount of timber, standing, on May 31, 1880, in the counties south of the Neuse river, at 5,229,000,000 feet. This, compared with the amount now standing in the same counties, shows a decrease of 2,000,000,000 feet in the amount of merchantable pine in thirteen and one-half years. At this rate of decrease in less than twenty years the long-leaf forests will be a thing of the past. The rate of decrease is, however, one of constant acceleration, since the yearly output of the mills is increasing and there is a much larger amount of abandoned orchard at the mercy of wind and fire.

At the end of twenty years there may remain scattered bodies of this pine remote from transportation facilities or too small to be profitably sawn, but there will be nothing more. The length of time the long-leaf pine will last can be stated with more certainty than in case of the loblolly pine, because in the case of the former there is no appreciable addition of merchantable timber from second growth woods.

The total amount of merchantable pine of all kinds (*loblolly, long-leaf, short-leaf* and *savanna*) in these Eastern North Carolina counties can be placed at about 8,200,000,000 feet, board measure.

The amount of standing swamp timber cannot be estimated with any degree of accuracy, since no average can be arrived at for the cut per acre, and only approximate figures can be gotten for the acreage. Cypress, for instance, will cut from 500 to 5,000 feet to the acre as a general thing, but numerous reports were made by trustworthy lumbermen of cuts running from 15,000 to 20,000 feet to the acre. There is a very wide range given for the amount of white cedar to the acre, but not so wide as that for cypress. The water oak and chestnut oak lands usually have a more uniform growth, and will cut from 1,500 to 3,000 feet to the acre. One of the chief difficulties connected with the handling of this oak, where such has been attempted, is that when green it has a greater specific gravity than water and cannot be floated out unless rafted with lighter woods. The same is true of the elm, hickory and much of the gum.

CHAPTER II.

THE WASTE LANDS OF EASTERN NORTH CAROLINA.

It is a very generally received opinion that the eastern part of North Carolina, especially that part covered with the long-leaf pine, is so densely wooded that for very many years at least there will be there not only an abundant supply of timber, but of a timber of the very finest quality. The long-leaf pine for nearly two hundred years has fully supplied all demands, not showing until very recently the least sign of failing. During the period between 1860 and 1870 the timber of the "pine barrens" was treated in a most reckless manner, and the fires which passed through them left traces which will last for many years to come, burning thousands of acres as clean as if they had been placed under cultivation. The timber which suffered most was that on the highest and driest land, where the ground was covered beneath the trees with a thick growth of wire-grass (*Aristida stricta* Mx.) and such broom grasses as grow on dry, sandy soil (*Andropogon tener* Kunt. and *A. Elliottii* Chap.).

The 3,100,000,000 feet of merchantable long-leaf pine still standing might seem to be sufficient to last for building and fence material in districts not readily accessible to large lumbermen for an indefinite time. But this is not so. The fact that since 1873 the output of turpentine in this State has fallen off over one-half, which of itself gives a very vivid idea of the number and extent of the turpentine orchards that have been abandoned, shows that it is now only a question of a few years before the turpentine yield will be reduced practically to nothing. This will mean that all the orchards have been abandoned, and it will be only a short time after their being abandoned before the destruction of the timber takes place, either by fire or by its being blown down, or by the two agencies combined.

The greater part of the dry upland soils of the pine belt are of two kinds: (1) the sandy loam soils of the level piney lands, and (2) the sandy soil, of nearly pure deep sand, characteristic of the *pine barrens* of the sand-hill regions. These barrens are dry and frequently form large tracts of rolling or even hilly land.

The first of these soils is not unproductive and is well adapted to agriculture; and as the original growth of long-leaf pine is removed from it the loblolly pine and a small growth of different kinds of oak, mostly the post, Spanish and black oaks, take its place. In the pine barrens, on the other hand, no oaks will flourish except two very small, worthless trees, the sand black-jack and the "barren" willow oak, and no pine except the long-leaf pine. Unless the soil has been previously cultivated the loblolly pine does not take posession of these lands, even when there are numerous trees of this species standing near by in wet places. From this it follows that when these high sandy lands are being stripped of their original growth of long-leaf pine, if its young growth is not allowed to develop, no tree of economic importance will naturally take its place. The sand black-jack oak in twenty years will have matured and begun to decay, while in that time a pine has only fairly begun its life, although its usefulness, even then, will be much greater than that of the more quickly maturing black-jack.

There are few uses to which the black-jack can be put. Its small size excludes it from being employed in construction; in contact with the soil it decays rapidly, and so is unfit for fence posts. It makes a very good fire-wood and is largely used for this purpose in Wilmington, Southport and other towns, and also in the country. Its bark is said to be valuable for tanning, but although the growth of this tree covers a very large area it is doubtful if the yield of bark per acre would be sufficient to make it of any commercial importance. The upland willow oak is even of less importance than the sand black-jack. While the presence of these trees is not pernicious, and is in fact much more beneficial to the land than would be a state of entire denudation of all forest growth, yet their growth is not near so valuable as that of the long-leaf pine, and the advantages arising from their presence are greatly inferior to those derived from a forest of the long-leaf pine of the same age. For this reason every means should be taken to enable the long-leaf pine to regain a firm hold on all high sandy land which has now on it no growth at all, or none of greater worth than the two oaks just referred to as growing on these lands.

SCARCITY OF TIMBER IN THE SAND-HILL REGIONS.

The exhaustion of the long-leaf pine forests is not a concern of the distant future alone,—something to be talked about and never to be realized. There are already localities, of limited area, to be sure, where there has never been a lumber mill, and with not one-tenth of the land under cultivation, where there is not now sufficient timber to properly fence the fields. The district around White Hall, Bladen county, is such a one, and this place is in the very centre of the long-leaf pine belt. Here good pine for fencing has become so scarce that a "stock law" or "no fence law" has been secured by which all live stock is to be confined to the Cape Fear river bottom, and that alone, fenced in across a bend of the river. There are other localities in Bladen, Sampson and Cumberland counties with about the same proportion of land under cultivation that find it hard each year to secure rails necessary for fence repairs, and obtaining them becomes annually more difficult as the forests from which the material is procured diminish in size. It is usually the case that some tree succeeds this pine as it is gradually cut off or otherwise destroyed, and this tree is usually the sand black-jack, and it forms over the land where the pine has once been a thicket of low, scrubby trees, which in less than twenty years will die and be replaced by a similar growth.

Scattered among these scrubby oaks are frequently stunted, knotty long-leaf pines, with a thin, sickly foliage of yellowish green, which are permitted to stand because they are regarded as useless. There are also large tracts of land on many acres of which there are no pines at all, and others where the black-jack even has not succeeded in getting a foothold, wire-grass and a few bushes being the extent of the vegetation.

THE LARGER TRACTS OF BARREN LAND.

Bladen county has its largest tract of this barren land in the northern part of the county, between the Cape Fear river on the south and Black river on the north-east, extending eastward as far as Lion swamp and west nearly as far as Parkersburg. It is about 18 miles long and from 4 to 10 miles broad, and has almost 70,000 acres of waste land in it. There are on it, however, a few bodies of pine in excellent condition, which either have not been boxed, or if boxed have been carefully protected; but for the most part it is covered with a scanty growth of sand black-jack, beneath which there is a great deal of densely tufted wire-grass, though in places there are only lichens and moss on the ground, or sometimes stretches of dazzling white sand. Here and there are small long-leaf pines, exhausted by the continued boxing.

In depressions where the soil is wet there are gallberry "bays" in which are a few savanna pines, but there is no loblolly pine except bordering the larger streams. These streams having loblolly pine along their banks are the Black and Cape Fear rivers, Colly swamp, Johns and Turnbull creeks. Colly swamp and Johns creek have in places a rich deep soil, formed of a fine silt largely mixed with organic matter, and could be easily drained. The drainage of Colly swamp for agricultural purposes is now being undertaken and it is probable that most of the swamp land will ultimately be drained, since it is much more fertile than the sand-barren uplands. This will mean, of course, the removal of the swamp timber. Although these streams have loblolly pine along their courses, its seed has never produced a young growth on any of the neighboring high sandy land; so that when the swamp timber is exhausted there will in reality be a dearth of building material throughout this region. The long-leaf pine timber from the tract was largely taken off to supply the mills at Wilmington, though much of it has been destroyed by fires. Even now some long-leaf pine timber, of an inferior quality, is obtained from here.

The surface of the land is gently rolling; the soil is nearly pure sand, with a small percentage of other mineral matter in it, and the subsoil, which is a light yellow sandy loam, lies too deep beneath it (from 8 to 15 feet below the surface) to be reached by the roots of trees. Generally there is no humus, the constant fires burning off the leaves and dead grass soon after they become dry. There are in Bladen county several smaller tracts of waste land, which lie south of the Cape Fear river.

IN SAMPSON COUNTY there is, perhaps, no single tract of waste land which covers an area as large as 10,000 acres. But beginning in the south-western section of the county, near Autryville, and following the Black river down, there are several small areas of from 3,000 to 8,000 acres, all of which areas are in a bad condition. These have been burnt over and in many instances are still covered with charred stumps or encumbered with fallen trees. The surface sand here is not as deep as in Bladen, the loam usually lying about three feet below the surface; nor is it as continuous, being cut across by Big swamp, Big and Little Coharie, and by several other swamps and streams. The population here is thicker than on the southern side of the river, and there is more cleared land, but there is as yet no scarcity of good timber. As the trees are here worked for turpentine longer than elsewhere in the State there are less abandoned orchards and the forests are better protected. The combined area of all the waste tracts in this county amounts to about 25,000 acres.

CUMBERLAND COUNTY has in its eastern part a continuation of the sand-hills of northern Bladen. The land in some places is more hilly, and the loam subsoil lies usually at such a depth below the surface (5 to 20 feet) that the roots of many trees do not reach it. The waste land lies mostly east of Fayetteville, all along Rock Fish creek, and south and east of Manchester. There are, however, many bodies of excellent timber in this latter section of the county. Along some of the creeks in the south-eastern part of the county the land is almost bare of all tree growth, while in other places, particularly in the north-eastern part, there is a heavy growth of sand black-jack, which has an average height of about 15 feet. There are at least 40,000 acres of such barren land in Cumberland county. Although not one-tenth of the soil is under cultivation several reports from the county state that in many places fencing material is becoming scarce.

Timber, other than the long-leaf pine, is not abundant in most parts of the county. The streams all have narrow channels and there is not much hardwood or loblolly pine along them. There are several white cedar "bays," but these can supply no building material. West of Fayetteville there is the same kind of soil that there is in the eastern part of the county, but there is much more timber standing. This part of the county is a succession of sand ridges and sand hills, which are covered with a fair growth of long-leaf pine. Nearly or quite all of this pine has been boxed, and although a considerable amount of lumbering has been done there remain large areas of valuable pine forests.

HARNETT COUNTY has in its southern parts a large area of waste land, which is in a worse condition than any other such tracts observed in the State. This is what is called the "Thomas Strange tract," which extends from the Lower Little river on the south to Little river on the north, and eastward 15 miles from Swann Station, on the C. F. & Y. V. R. R. This tract contains over 40,000 acres of waste land, two-thirds of which has but few merchantable pines on it and scarcely any sand black-jack. All of this except the part immediately adjacent to the railroad was reduced to its present condition by repeated forest fires, the thick wire-grass forming the fuel which carried the flames. The territory along the C. F. & Y. V. R. R. has been lumbered and there is still some lumbering operations going on along it where there are bodies of timber which have been protected from the fires.

The topography of the southern part of Harnett is similar to that of Cumberland. It is a typical "sand-hill" region, and its soil is sand with the loam lying very deep below the surface. The streams usually have narrow channels and very little hardwood or loblolly pine along them; but along Upper Little river and the Cape Fear there are in places wide and well-timbered "bottoms." The northern part of the county has a salmon-colored gravelly loam soil on which loblolly pine and white oaks are replacing the long-leaf pine. In the western part of the county and extending east from Jonesboro there is another tract which was burnt over several years ago and much of the timber on it destroyed. This latter area is not "waste land" now, but it soon will be. Harnett county, being intersected by the Cape Fear river and two of its largest tributaries which afford transportation facilities, furnishes yearly a considerable amount of timber (long-leaf pine) for the Wilmington mills.

MOORE COUNTY has 60,000 acres of waste land, all of which has been recently lumbered, though much of it has been burnt off subsequently. This land has a heavy growth of young sand black-jack on it, and in the localities more recently lumbered there remain a few scattered pines. It lies in the eastern and southern parts of the county, along the railroads. In places there are some post and spanish oaks with the sand black-jack oak, but there is almost no loblolly pine and no other material suitable for building purposes except the long-leaf pine. When lumbering has ceased there will probably be over twice the area of waste land there now is, since all the southern section of the county is high rolling pine barrens, with a deep sandy soil.

RICHMOND COUNTY has a soil in character similar to that of the southern part of Moore; but since lumbering has not been so extensively carried on in Richmond as in Moore there are in the former only about 40,000 acres of waste land, all of which have been lumbered except a few small tracts which have been burnt over. This waste land lies along the C. C. and R. & A. R. R's. It is covered with a thick growth of sand black-jack oak, and there are undersized pines scattered over a part of the area, many of them still being worked for turpentine. Except the long-leaf pine there is very little timber in the eastern part of the county suitable for building material.

ROBESON COUNTY has very little waste land and very little deep sand except in the northern part of the county. In that section, adjacent to the Cape Fear river, there are possibly 10,000 acres with little tree growth except sand black-jack oak. In the middle and southern parts of the county the loblolly pine is taking the place of the long-leaf pine.

BRUNSWICK COUNTY contains several thousand acres of waste and very thinly timbered lands along or near the sea-coast and the Cape Fear river. While these lands were never heavily timbered they are now rapidly getting into a deplorable state, which is a presage of the final destruction of the long-leaf pine.

COLUMBUS COUNTY has about as much waste land as Brunswick. This land is in small tracts lying in the southern part of the county and the sand black-jack oak has taken possession of most of it. Good loblolly pine is, however, abundant through most sections of this county.

WAYNE COUNTY has 20,000 or more acres of waste land covered only with sand black-jack oak and very scattering, exhausted long-leaf pines. This land lies in the central and southern parts of the county. Good timber is getting scarce in many places. Much of this sandy land in this and other counties has been highly fertilized and is cultivated in truck farms, vineyards and fruit orchards.

DUPLIN COUNTY contains several thousand acres, in the northern part, covered only with the sand black-jack oak, through which, occasionally, there occurs a few scattering long-leaf pines. Near the railroads a great deal of this sandy land, which has been highly fertilized, is used in this county for truck gardening.

ONSLOW AND NEW HANOVER COUNTIES have jointly about 25,000 acres of waste land, some of which is entirely denuded and some covered only with the sand black-jack oak. In many parts of New Hanover county, especially between Wilmington and Wrightsville, there is a very promising regrowth of long-leaf pine appearing, though the trees are very scattering and fires destroy a great many of the smaller ones every spring. The growth of timber in the eastern parts of New Hanover and Onslow counties, like that in the eastern part of Brunswick county, was probably never dense.

Besides the above tracts there are in *Johnston*, *Pender* and *Lenoir* counties a few smaller tracts which have been stripped of the long-leaf pine and on which no valuable regrowth has appeared; and there is immediately along the coasts of *Currituck*, *Dare* and *Carteret* counties a narrow strip of land which in many places is entirely bare, and has been described by the late Prof. W. C. Kerr as forming drifting sand dunes, which, along the coast of Dare county, "are moving under the impact of the trade winds constantly toward the south-west into the sound." What effect these moving dunes may have on the existing channels in the sounds or how they may modify or change the inlets between the sounds and the ocean are questions foreign to the present subject.

It is a well-known fact, however, that the breaking of the ocean, in 1763, through one of these untimbered sand banks formed the *New Inlet*, 16 miles below Wilmington, N. C.; and seriously changed the channel at the mouth of the Cape Fear river, lessened the depth of its water and caused the expenditure of a large amount of money before the damage done could be rectified and the break securely filled. It could not be learnt whether this strip of sand dunes was ever timbered, though it is probable that at one time it was, since Smith's island and other parts of this same bank only a few miles distant are now heavily timbered.

THE ORIGIN OF THE WASTE LANDS.

From the preceding it appears that there is a large amount of waste land lying in the south-eastern part of this State. There are now over 400,000 acres of such land and the amount of it, from various causes, is constantly increasing. This land consists of high, rolling or hilly sand barrens, formerly covered with extensive forests of long-leaf pine. These forests yielded turpentine abundantly, but on account of the larger amount of sapwood and the coarser grain of the wood of trees growing on these poorer sandy lands the lumber, though of good quality, was of a grade inferior to that from trees grown on fertile soils. Now, however, owing to the grossest neglect, large portions of these forests have either been destroyed entirely or reduced to such a condition that there is neither mill nor turpentine timber on them, and no regrowth of the long-leaf pine has been allowed to take the place of the older trees as the latter were being gradually exterminated. The soils of the barrens on account of their sandiness and poor quality will produce very few kinds of trees which have any economic importance. No valuable broad-leaved trees (oaks, etc.) thrive on these lands, and among the conifers (pines, etc.) the long-leaf pine is the only one growing naturally on them.

The short-leaf pine, except where the loam subsoil lies near the surface, is rarely found, and it is only after the ground has been cultivated and enriched and the moister layers of earth have been brought to the surface that the loblolly pine will grow there. So it seems that the long-leaf pine is the only native tree of much value which flourishes on these barren, sandy lands. There are very few if any other forests in the eastern United States so peculiarly limited as to the variety of valuable tree growth as the long-leaf pine forests, particularly when it grows on the sand barrens; and there are no other forests which demand such care to obtain a regrowth of the original dominant species.

Many kinds of trees after having been lumbered or burnt out are succeeded by smaller and less valued species, but the original growth in time again takes possession of the land. This is the case with the spruce forests of Western North Carolina and the white cedar (juniper) in the eastern section of the State. However it may have been primarily in the long-leaf pine forests this is not the result under the present management of these pineries. After the removal of the pine the land quickly becomes waste land, and passes from a growth of sand black-jack to utter barrenness. Nowhere is there any general sign of either the long-leaf or any other pine again forming a prominent part of the growth on these sand-hills.

Unless there is some radical change in their management these lands may even cease to produce the few sand black-jack oaks which now flourish on them. There is even a possibility, and in fact it can be said a great likelihood, that this valuable tree, the long-leaf pine, will become extinct in North Carolina unless some steps are taken to secure its more general propagation. It has already become extinct over large tracts lying to the north of the Neuse river which were formerly occupied either exclusively by this pine or by mixed forests of it and hardwoods and the loblolly pine.

WHY LONG-LEAF PINE FORESTS ARE NOT SELF-PROPAGATING.

The causes which have operated to prevent the long-leaf pine from propagating itself are several, and all of them are important and act uniformly throughout this sandy area. A brief statement of some of the peculiarities of this tree may enable us to see more clearly why it needs more special protection than must necessarily be accorded other trees to enable the forests to reproduce themselves. The chief causes which have influenced and tended to retard the general regrowth of this tree at the present time arise from a highly specialized form of seed and plant structure and a decidedly unique manner of growth when compared with the other pines of this same region. These characteristic peculiarities lie chiefly in the young pine seedling, in the seed, and in the structure of the leaf buds.

THE SEEDING OF THE LONG-LEAF PINE.

Although the writer has not yet carried on systematic observations, on (1) the frequency of seeding of the long-leaf pine, (2) the relative abundance of its seed as compared with those of other pines, and (3) the relative fertility of boxed and unboxed trees of the same species, long enough to have obtained accurate results, yet the observations of different persons, thoroughly familiar, for many years, with the pines of the barrens, will, he thinks, for most of these cases, be found sufficiently accurate, their results being supplemented by his conclusions drawn from a personal investigation extending over several years. Although there were certain years in the primeval or virgin long-leaf pine forest, just as there are with all other trees, when no seed were borne, yet these years were rare and the yield of seed was usually abundant. William Byrd, writing in 1728, says* the mast of this tree (the long-leaf pine) is very much esteemed for fattening hogs, through all of Albemarle county (North-eastern North Carolina) on account of its greater abundance and the greater certainty of its occurrence (than that of the oaks). The forests of which he was speaking were largely virgin at that date. There are to be found frequent statements mentioning the same fact by other historians, of both an earlier and later date.

So far as could be ascertained the masts (as the seed of this pine are called) have not been as abundant for the past fifty years as they formerly were. There seems to have been only three large long-leaf pine masts since 1845. One of these occurred just about that time, the next one was in 1872 and there was one in 1892, which was not so large, however, as either of the preceding. There is a fairly abundant mast about every four or five years, and on intermediate years the production is small and localized. In North Carolina most of the trees which now bear seed are boxed and have been in this condition for from ten to fifty years. And the opinion prevails throughout the pine barrens that pine masts are less frequent and less abundant now than before the pines were so largely boxed and thinned out. The removal of a great portion of the trees may explain, in part or wholly, why masts are less abundant. It would naturally be inferred that there would be a large decrease in the productiveness of boxed trees, whose vitality, measured by the rate of accretion between them and unboxed trees, has been greatly impaired by the practiced manner of boxing. However, from a tabulated record of observations carried on during several years there as yet appears no marked difference between the productiveness of boxed and unboxed trees, similarly situated.

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*History of the Dividing Line between Virginia and North Carolina, p. 29.

There are several important differences between the reproductive capacities of the loblolly and long-leaf pines, all of them to the advantage of the former. The fertility of the long-leaf pine is much less than that of the loblolly pine, its most frequent associate. The loblolly pine bears cones at an earlier age, and usually produces more seed, both perfect and imperfect ones, and the great variety of soil on which the loblolly pines grow causes a slight difference in the time of flowering of different trees, making this pine less liable to have the entire prospect of a seed yield destroyed by frosts, or by heavy rains during pollination. While this may possibly explain why the loblolly pine has come up as a regrowth over so much of the moister loam land it has affected the growth of the pine barrens very little.

The seed of the long-leaf pine are very large, one-third to one-half an inch long, independent of the wing, while no other pine of this region has seed over one-fourth an inch long. But there is a much smaller proportion of abortive and otherwise imperfect seed in a long-leaf pine cone than in the cone of the loblolly pine. This would be decidedly to the advantage of the long-leaf pine in seeding old fields, etc., were its seed not too heavy to be carried far by the wind. They usually fall within fifty feet of the parent tree, while the light-winged seed of the loblolly have been known to scatter thickly over fields from trees more than a quarter of a mile distant; and single seed are reported to have been blown several miles. And furthermore, as described more fully beyond, the seed of the long-leaf pine are much more extensively destroyed by hogs, fowls, squirrels, rats, etc.

Another reason for the exclusively loblolly growth in fields may be that even when the seed of the two pines fall on the same land the loblolly pine by its rapid growth during the first few years overshadows and effectually crowds out the more slowly growing long-leaf pine, and the latter during this early slow growth are easily destroyed by fires and by live stock. The two are, however, rarely seen associated together in second growth woods. The seed ripening in October fall to the ground rapidly and if there is a warm moist season sprout immediately. In the event of a long warm rain just after the seed are matured they will frequently sprout in the cones and the entire yield will be thus destroyed.

DESTRUCTION OF THE YOUNG PLANTS.

The young long-leaf pine seems to be especially adapted by the form of its root system for growing on a sandy soil. By the end of its first year's growth its root system, which has grown rapidly, consists of a large tap-root which extends 6 to 10 inches deep in the sand, and from the bottom of it branches out the smaller roots which draw nourishment from the soil. It is this deep-seated root system sent thus early far down into the soil which enables this pine to grow on the sand barrens, and it is doubtless because the roots of the loblolly are small and divide for the first year or two into a great many small divisions, lying near the surface, that it does not get sufficient moisture and nourishment from the dry surface sand to enable it to thrive on the sand barrens before this land has been cultivated. This long tap-root of the long-leaf pine frequently goes through the sand into the loam soil and secures for the tree a firm anchorage against storms and enables it to draw its nourishment from a more fertile soil.

The stem parts of the long-leaf pine are as peculiarly adapted for growing on a sand soil as the root system is. Instead of the stem's branching or growing the first year it only puts out a great number of very long thick leaves, exceedingly close to the ground. These leaves soon spread out and help to shade the ground close to the plant and keep it moist. At the end of the first season's growth the single (terminal) bud is not over an inch and a half above the earth and the bud itself is nearly an inch long, so that it can be said that the stem of the seedling does not grow any in height during the first year, all the energy of the plant being diverted to increasing the root and producing the great tuft of long deep green leaves which spread out immediately below the bud and make the plant resemble more a tuft of some marvelous kind of grass than a young tree. Some of the lowest leaves usually die during the first year; most of them remain on, however, for two seasons.

During the second and third years the growth of the stem in height is slight, though it increases in thickness, but after that, at least in a forest, its growth is wonderful. Frequently in a thick wood where a young tree has been allowed to grow, in 8 or 9 years after height-growth has begun, it will have reached a height of 18 or 20 feet and a diameter of no more than 3 or 4 inches, and will have grown each year from only one bud, the terminal bud, at the end of the woody axis, there being no branches, and no sign of any having been formed. For leaves there will be only a single, broom-like bunch terminating the slender stem. The rapidity with which this stem is raised and the fewness of its branches until the natural height of the tree is reached makes one of the fine qualities of the timber. It gives long stocks which have no knots in them, even small ones, to produce any ununiformity of quality, or to make weak places on the interior of an apparently perfect piece of timber.

This feature which is the cause of so fine a quality of wood is a great drawback to the development of the young trees. This single terminal bud is a very large and complicated structure, and when once destroyed in any way no other bud is usually formed by which the growth of the young seedling can be continued. It is true of most conifers (*i. e.*, pines, firs, cypress and cedars) that they do not readily form buds and that they rarely sprout from the stump and are very difficult to reproduce from cuttings, etc., but with the long-leaf pine such buds are formed and sprouts developed even more rarely than with most other conifers.

THE ENEMIES OF THE LONG-LEAF PINE.

The long-leaf pine has a severer struggle for existence than any other of our forest trees for the reason that in all stages of its reproduction and growth it is more severely and continuously attacked by a greater variety of enemies than any other. Besides the natural drawbacks to its development from the peculiar manner of forming several of its parts, and the fact that these parts when destroyed are not replaced, its large and sweet seed are eaten in large quantities by *fowl* of various kinds, *rats*, *squirrels*, and by *swine*, which prefer them to all other kinds of mast and, when there is enough long-leaf pine mast, become very fat on it.

As far as has been observed, young long-leaf pines are attacked by no injurious beetles or bark-borers or by any fungi sufficiently to injure them. The mature pines, however, have in past years several times been attacked by bark beetles in such numbers as to destroy the pine over large areas. A few trees which have been killed from their attacks can be seen at any time around the edges of districts where lumbering is in progress, or about districts which have been recently lumbered.

DESTRUCTIVE WORK BY HOGS AND FIRES.

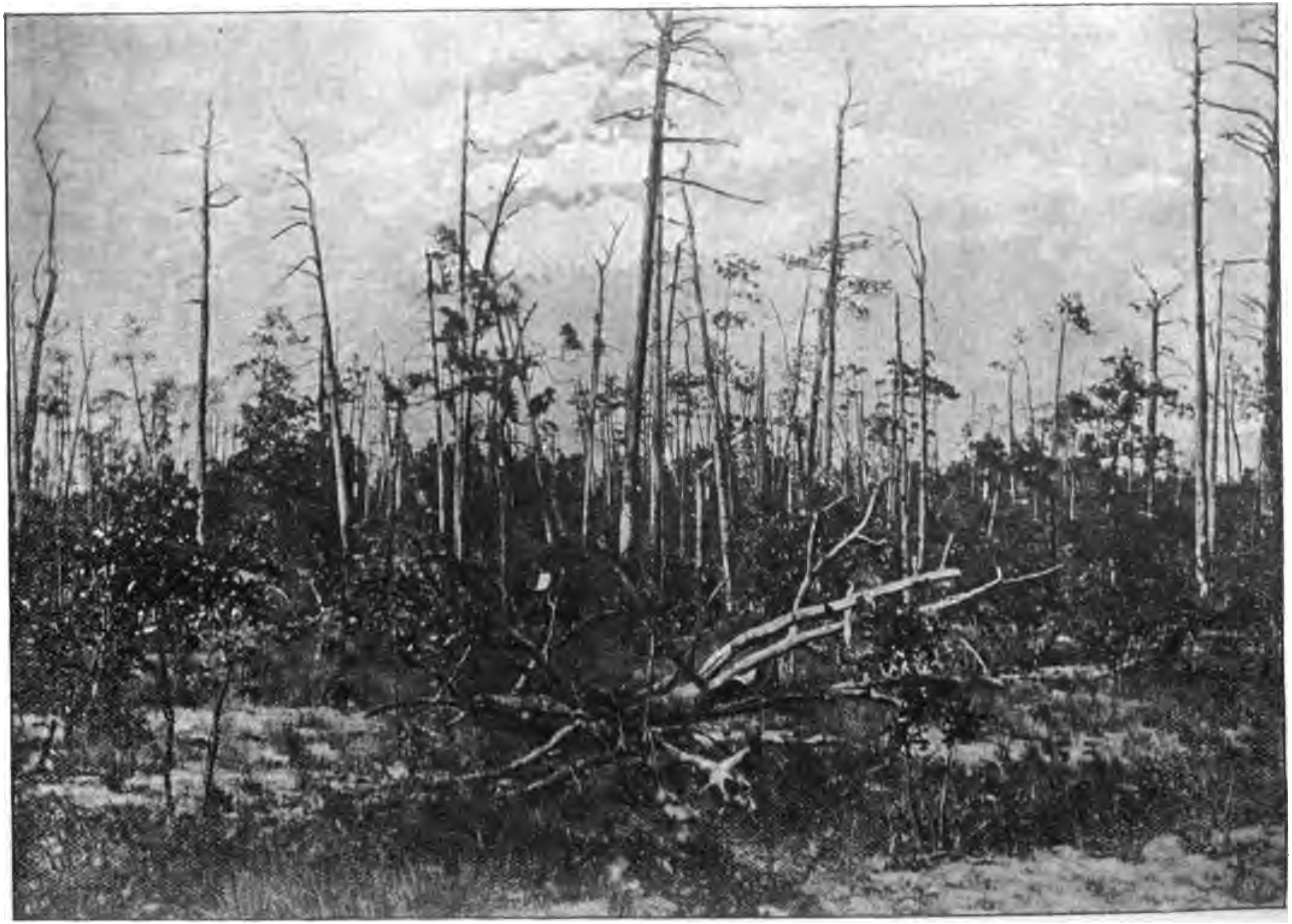
If the destruction by swine ceased with eating mast there would still be sufficient seed left to reproduce some parts of the forests, as the mature trees are gradually thinned out, for one-year-old seedlings are common twelve months after a heavy mast. No sooner, however, has the young pine gotten a foot high and its root an inch in diameter than the hog attacks it, this time eating the roots, which, until two inches in diameter, are very tender, juicy, pleasantly flavored and free of resinous matter. In the loose sandy soil the piney woods hog, or "rooter," finds little difficulty in following and devouring these tender roots to their smallest ends. Many small trees are destroyed in this way. And cattle, furthermore, are said to bite off frequently the tops of the small plants, and with them the terminal buds, in the early spring. This is doubtless done while grazing, more accidentally than otherwise.

Fires often destroy all the young pines that escape the hogs. They kill the small pines by burning the highly inflammable bracts around the bud and so stop its growth, or in high grass frequently burn all the leaves. Larger trees, even until they are 3 or 4 inches through, are easily killed in spring, when the sap is rising and the outer layer of wood is growing rapidly, by a hot fire which will burn the thin exfoliated layers of bark all over the trunk. The loblolly pine is less injured by fire because its bark is thicker and so offers more protection to the growing wood; the bark, too, lying closer to the wood in firmly appressed layers, does not so easily take fire. (See, also, the discussion on page 61).

The chief agencies, then, which prevent a regrowth of the long-leaf pine on the high sandy lands are the hogs and the fires; and the attacks of the hogs are directed against parts which seem to have been developed to meet requirements of a plant growing on a dry, barren soil of loose sand. These peculiarly developed parts are the seed, large for a pine, which contain abundant nutriment for the young plant to enable the root to push itself rapidly into the sand; and the long, succulent root which grows for a considerable distance straight down without branching. Since the first settlement of these sandy lands the "ranging" of swine has been allowed in the barrens, and while there were enough pines standing and frequent masts, they fed a large number of hogs.

The practice of firing the barrens has been adopted in many cases with a view to improving the pasturage; while in many other cases, after the trees were boxed, the leaves and trash pulled away from around them, the forests were burned over to prevent in a dry season a chance conflagration getting from under control and burning the faces of the turpentine boxes and the timber. That this policy of burning the barrens is a very bad one and calculated to do far greater damage than that immediately apparent has perhaps been made evident. The accompanying illustration (Plate I) shows one of these long-leaf pine forests, near Southern Pines, where a recent fire destroyed all of the young growth, the turpentine boxes and most of the timber trees.

That sooner or later the present management, or lack of management, which has characterized all dealings with the barrens for the past 150 years must be changed if the long-leaf pine forests are to be made self-propagating, no one who has ever seen their condition or fully realizes what it is can possibly doubt. The logical result of these burnings in the past has been the destruction of millions of feet of standing pine and the prevention of the growth of young trees, which, had they started even fifty years ago would



LONG-LEAF PINE FOREST A FEW MONTHS AFTER THE FIRE; MOORE COUNTY.

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now be large enough for small mill timber and for turpentine; while the burnings of the present and future, if not soon discontinued, will mean the final extinction of the long-leaf pine in this State.

THE ULTIMATE UTILITY OF THESE WASTE LANDS.

It has been practically demonstrated, in the vicinity of Southern Pines and elsewhere, that, after having been richly fertilized, considerable portions of these sandy pine-barren lands, containing a small portion of loam and organic matter mixed with the sand, are adapted, by their southern situation and light, friable soil, to a high state of productiveness in fruits and vegetables; and these branches of agriculture are rapidly increasing in North Carolina. They appear to be more especially suited for vinticulture and gardening. It is probable, however, that large portions of these waste lands will not be brought into cultivation during the next fifty years, nor at any time, owing to the extreme poverty of the soil. What then is to be done with this 400,000 acres, once covered with long-leaf pine, but now of little more value than a similar area of a genuine desert? If the present lack of policy in regard to their management is continued, it is only a matter of a few years before the long-leaf pine which is now standing on the sand-hills will also have been destroyed without giving profitable returns to its owners or leaving behind it a young growth of pine to take its place. It becomes manifest at once that if the scattering trees, which might serve as seed trees, are entirely removed from this waste land, it will not only be a very difficult but a very costly matter to secure a regrowth of long-leaf pine or any other valuable building tree, either pine or hardwood.

No matter what is the ultimate use to which the land may be put there must necessarily be, on a considerable part of it, trees which grow large enough to furnish timber and fuel more abundantly than the black-jack oak can do. A pine alone can supply such wants when there is only an impoverished soil to grow on, and the long-leaf pine can do this better than any other pine.

No community, least of all one devoted to agriculture, no matter whether it raises cotton, garden truck or fruit, can be independent while at the same time it is dependent on some other section for either fuel or building material. This, however, is what some sections of eastern North Carolina are fast coming to, and the fact is being recognized by not a few of their most thoughtful residents.

That the existence of a highly developed agriculture is sometimes entirely dependent on a forest is shown by the condition of the lands between Bordeaux and the coast of France along the bay of Biscay. This district is the seat of the manufacture of the Bordelais wines, clarets and other light wines, and some of the finest wines are made in vineyards east of the Médoc from vines grown on a highly sandy soil. A great part of this land is covered with forests of pines, which were set out, at great expense, to prevent the shifting of these sandy soils. Before the planting of the forests these lands were sand dunes, or heather lands which formed dunes of moving sand as rapidly as the low, scattered heath growth was removed.

In view of the facts stated in the preceding pages we are driven to the conclusion that the most practicable plan of treatment of these waste lands, with a view of making them again productive of wealth to their owners, is that of protecting these areas against the attacks of hogs and forest fires and thus permitting them to be again covered with a new growth of long-leaf pine.

COST OF SECURING A NEW FOREST GROWTH.

The cost of securing a regrowth of long-leaf pine on most of this waste land would now be very little in addition to what the land-owners must necessarily pay to retain their land which has ceased to be productive or give any returns. Interest on the capital invested in the land probably has to be paid and taxes must be paid yearly. The additional cost would be solely that arising from protecting the land from fire and from excluding cattle and swine for a certain number of years after a mast.

The opposition such a measure would produce would be considerable, especially among a class of indigent citizens who, owning little or no land themselves, have always been accustomed to give their cattle free range over the lands of others, to fire the dead grass for bettering the pasturage, and even to cut timber for home use on these lands *ad libitum*. It is the opposition of these people, who constitute so large a part of the voters, that has prevented in several of these eastern counties the adoption of a general law for confining cattle and stock. As timber for fencing material and other purposes becomes scarcer, the more intelligent citizens are coming to see clearly enough the imperative need of such a change, both in our laws and in public opinion, as will suffice to protect the young forest growth from fires and stock, and thus to give the valuable forest trees an opportunity to propagate themselves.

NECESSARY PROTECTION OF YOUNG PINES AGAINST FIRES AND HOGS.

Without a thorough cessation of fires and an equally thorough exclusion of stock, at least until the trees are thickly started and well grown, say until 10 feet high, any effort to produce a uniform growth would be futile. Once that a new growth has secured a firm foothold and has formed a dense covering, the very thickness of it, by its exclusion of most low growth and grass, will be preventive of fires, since the thin covering of pine straw and humus will not carry fire except in very dry seasons or before a heavy wind. The exclusion of swine is a measure which must be absolutely enforced until the trees have reached a diameter of 3 or 4 inches. (See, also, page 57).

The following statements will show what an important part fires play in the destruction of pine seedlings:

In the fall of 1892 there was a very full long-leaf pine mast, and in the following spring seedlings could be seen by thousands. In moderately dense long-leaf pine forests in Montgomery county, where there was about one-half as many of those pines standing as when it was in a virgin state, these pines being mixed with a few post and black-jack oaks and the rest of the land open, there were from 15 seedlings to the square yard in the open to 35 seedlings on an equal area beneath some of the trees. A space which was staked off and noted was examined again in the fall after a fire had passed over it and then it did not average one seedling to the square yard. The soil here was a salmon-colored loam and the grass largely broom-straw (*Andropogon Virginicus*).

Another tract, which was on the sand-hills of the western section of Cumberland county, was examined shortly after it had been lumbered. This was not seen in the spring, but when visited in the fall showed by the great number and position of the cones that seed must have fallen abundantly over most of the ground which had since been burnt over. It was hard to find, however, a seedling which had escaped the flames.

Another place examined was in Bladen county, on a sandy loam soil. There were in the spring of 1893 numerous seedling pines there. A later examination in the fall showed a large number still growing, but no fire had passed over them and the roots were not yet large enough for the hogs to root up. A small portion of this last tract has been fenced off and the progress of the seedlings in the enclosure, and those outside, will be compared and the requirements and peculiarities of the young plants studied as they develop.

If it had been possible, immediately after the falling of this mast of 1892, to put the long-leaf pine lands, or at least those parts which are most sandy, and have only a thin cover of pines, or the large areas recently lumbered, under some management which would have given protection to the seed and later to the young pines, in ten years with continued protection there would have been over the larger part of this area a thicket of pines large enough to have been self-protecting in a great measure, and in a fair way to become trees suitable for lumber and for yielding supplies of turpentine.

At the date of this writing it is a safe statement to make that there have been already destroyed over nine-tenths of the pines which sprung up so abundantly less than two years ago. The time which will elapse before another large mast is of course uncertain. Smaller masts should occur, however, in three or four years. Last year (1893) there was none. An examination of the pines shows that there will be very little this fall. The freeze in April of this year (1894) destroyed the pollen of the trees along the western part of the pine belt, but as they have not been examined further east it is uncertain whether it was destroyed there also.

There will consequently be little pine mast in 1895, at least in the western parts of the long-leaf pine belt, as it requires two seasons for growth and maturity after pollination has taken place.

FOREST MANAGEMENT IN THE WASTE–LAND REGIONS.

Just here, in connection with the discussion as to what policy should be adopted in regard to the treatment of the pine barrens, a brief statement of what forestry is and what it necessarily is not, will not be out of place. The two conceptions as to what forestry is are in part equally erroneous. One of these is that forest management consists in protecting trees with no definite end in view beyond that of protection. The other conception contains a half truth. It is that forest management consists in the production of trees and the systematic management of timbered lands, but that the State or government's ownership of such timbered lands is essential for putting this into practice. This latter view of the matter is fairly correct except that ownership or management by the State or government is by no means an essential feature. In a country such as ours timber lands must be managed by their owners or not at all.

From the point of view of a money-yielding investment, and this is the chief view that need be considered in dealing with most of the lands of eastern North Carolina, the following might stand for a definition of forestry: Forestry consists in the systematic care of forests so that the land will always yield valuable forest trees and so that production of timber may be carried to its highest possible limits. This growth of course is to be utilized, *but in such a manner that a young growth of equal value to the one removed may take its place.* Such management is not only not inconsistent with private ownership of land, but if properly carried out by private parties can be made more efficacious, at least as far as financial results are concerned, than when carried on by a government or State.

It is true that in some European countries much of the forest is owned by the various governments, municipalities, etc., but much of this land was owned by the respective governments for many years before any forest management was practiced. Their ownership by the governments was not at all necessary for the practice of forestry in these countries, and there is more forest land under systematic management in Europe owned by private parties than by the governments.

In some of the private forests, as those of the Tyrol, cuttings are restricted and are superintended by trained government foresters, because from the situation of the lands in hilly or mountainous districts the sudden removal of all timber from over a large area might cause the land to wash, so that reforestation could only be accomplished under serious difficulties. The clearing of large areas and their remaining in a state of denudation causes in hilly countries, where the soil washes easily, great floods in the rivers which are filled with *detritus* washed down from the hills. Such floods endanger the life and property along the streams, while the deposit of the soil washed down seriously affects arable lands and the channels of the streams. The control of such lands as these is not undertaken by the governments with a view of influencing in any way the owners' profit, but as a measure to protect other citizens whose interests might be much affected by any carelessness or greed of a timber owner.

In Germany, which country probably leads the world in the thoroughness of its forest management, there are about 43,000 square miles of forest.* The government owns about 13,300 square miles of it, various local organizations, towns and small principalities own 6,700 square miles, while the rest, about 21,700 square miles, belongs to individuals, and its management is entirely free from all governmental interference, except so far as the cutting of one person's timber will damage lands or property belonging to another, in which case an injunction to prevent cutting can be obtained from the courts.

THE NECESSITY FOR FORESTS IN THE FUTURE.

The question is asked, Will there be any use, fifty years from now, for a forest grown on this waste land when so large a part of the State and country will be timbered by a second growth of pines and hardwoods which have naturally sprung up? Moreover, it may be thought that in that length of time a large part of the original forest growth will still remain uncut.

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*Paul Pary's Yahrbuch, 1890. Landwirtschaftliche Statistik, 1889.

An examination of the facts in the case will yield an answer. Ten years ago it was thought that the supply of white pine was inexhaustible in Michigan, which State then had far the largest bodies of pine, and in fact nearly all the merchantable white pine in the United States except that in Wisconsin, Minnesota and some in West Virginia. Bulletin No. 5 of the Eleventh U. S. Census showed that in 1890 Michigan had an output of white pine of about 10,000,000,000 feet, board measure (including shingles), and that there was supposed to be only enough timber standing to last the mills for five years longer. Many persons even then ridiculed the idea of the exhaustion of the white pine. A few months ago the *Northwestern Lumberman*, which had most loudly proclaimed that the white pine was inexhaustible, announced that this season there would be in one district a shortage amounting to many million feet, and that the total shortage in Michigan alone would probably amount to over a billion feet, board measure. Other soft woods, yellow poplar, etc., will probably be sawn to take its place for several years, and will come from Kentucky, Tennessee, North Carolina and other regions in the Appalachian mountains.

In ten years from now the forests of Michigan will have been a thing of the past, so that within fifty years after lumbering began on a commercial scale the white pine and probably the best hardwoods will have been cut out. These forests of Michigan cut from two to three times as much mixed hardwood and pine to the acre as the pine lands of eastern North Carolina will now yield, after having been picked over for two hundred years.

The forests of Washington are as yet in a nearly virgin condition and are probably the finest in the world. They will cut three times as much to the acre as the pine lands of eastern North Carolina, and although the amount of standing timber was estimated on January 1, 1894, to be near 400,000,000,000 feet, board measure, yet such is the enormous destruction of timber by fire and the rapid increase in the milling industry, which now cuts only 1,000,000,000 feet a year in that State, that those forests will probably not last longer than fifty years.

The forests of all the Northern States have been cut over and the most valuable timber removed. Maine, Vermont, western Pennsylvania and West Virginia still manufacture, however, large quantities of hardwoods, but the supply of them is so rapidly being reduced that in a few years the annual output will be reduced to the growth in the forests during a year.

The condition of the timbered lands is about the same in all the Southern States. The pine in the lower districts has in places been entirely removed, but in other places there is still much left, while the hardwood on the uplands has for a century been called upon to supply local needs and in most places has had the finest timber culled, except toward the mountains of the south-eastern States where there are magnificent virgin forests of hardwoods. These forests of the South are the ones to which the lumbermen of the North are looking as the supply of timber near the seats of consumption becomes exhausted, and once that the tide of millmen turns this way the depletion of the forests of this State and those farther south will be a matter of only a few years.

Bulletin No. 5 of the Eleventh U. S. Census gives the amount of yellow pine and cypress land owned in nine Southern States by establishments located only in Michigan and Wisconsin to be 1,407,358 acres, estimated to have standing on them a total product of eleven billion feet, board measure, of merchantable timber, valued at $8,723,000. The timber on this land is cypress and hard pines—*i. e.*, long-leaf, loblolly, and short-leaf pines, and this large amount invested shows that Michigan millmen, already foreseeing the exhaustion of the northern forests, are investing in those timbers which are suitable to take the place of the white pine. Even at the present rate of removal, and allowing that there is no decrease in the business from the free entrance into the United States of Canadian lumber, the standing pine in the eastern part of North Carolina cannot last twenty years, and may not last more than fifteen years, unless a wise policy obtains. The indications are, however, that there will be in the next five years a much greater expansion of the milling industry in eastern North Carolina than has taken place during the past five years and a proportionally greater increase in the annual output of lumber, and decrease in the available supply of standing timber.

WILL A REGROWTH OF PINES ON THESE WASTE LANDS PAY?

This question has been asked; and it is the first point to be considered in connection with any attempt to restock these waste lands with long-leaf pine. And in answering this question we may ask another: Will it pay to let these lands lie idle and unproductive? The cost of securing a growth of pines on these lands will be the cost of keeping off the hogs and fires, and this will be but little if any more than what proprietors have to pay at present for the privilege of holding these unproductive tracts. If it pays to own these lands unoccupied and unproductive, it will pay much better to own them if they are restocked, at a slight cost, with long-leaf pines.

One of the chief considerations upon which the final value of a regrowth of long-leaf pine depends is the securing, in as short a time as possible, a thick, homogeneous growth of young trees, and the entire prevention of all fires among the pines. Nowhere else is the truth of the strength of unity more exemplified than in a forest growth, especially in a young and growing forest, on an arid and impoverished soil, where one of the necessities is retaining the moisture in the earth and preserving the humus formed by the decay of leaves. This moisture will serve to supply the trees with water essential for their development and tend to check or even prevent fires. The damage fires do to a forest growth, even after the growth is well started, is considerable and has much influence on the character of the timber. By killing a part of the timber they make the growth open and the stocks short-bodied and filled with limbs and resulting knots. The thicker the growth the taller and straighter will the stocks be, and so much greater and more valuable will be the *final* yield of timber.

RATE OF GROWTH OF LONG-LEAF PINES.

After a large number of measurements of young growth trees, which have sprung up in enclosures, or where protected, it has been ascertained that it will require from thirty-five to fifty years for such a growth to reach sufficient size to furnish saw logs 20 feet long and from 14 to 20 inches in diameter. The usefulness of these trees will have begun, however, in less than half of that time, since their increase in size is much more rapid during the earlier years of growth than during the later years. After twenty-five years they will be large enough to hold a turpentine box. About this age, too, they begin to bear mast, and as the foliage becomes more open the more tender grasses of the barrens appear and afford pasturage. Besides this there is a great quantity of litter which yearly accumulates under the trees and can be used, as such litter now is, when it can be gotten, as a mulch for agricultural lands. Moreover, the lands themselves will have gained a permanent improvement from the mould which will have accumulated on the ground during the time that the trees were growing.

FUTURE VALUE OF TURPENTINE ORCHARDS.

What may be the value of turpentine orchards twenty years hence is of course a speculative question. With the great variety of uses to which both rosin and turpentine are put it is hardly likely that in that time any cheaper substitute will be found for them in all their uses.* The area of long-leaf pine which will be under orchard at that date is also largely a matter of conjecture. The observations of the writer and of several specialists who have examined all or parts of the territory covered by the long-leaf pine, would lead to the conclusion that, without some radical change in the manner of boxing, and the reservation by timber owners of large tracts of pine for turpentine culture only, the orchards of the United States, with the possible exception of those of Texas, will have seen their best days in less than twenty years.

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*Uses of Resinous Products.—In a report upon the maritime pines made in 1878 by M. Desnoyers at the Universal Exposition of Paris the following uses are given for the different resinous products of that tree:

Spirits of turpentine is used in the manufacture of oil colors, varnishes and paints, in the preparation of rubber, is employed in medicine and veterinary arts, and for cleaning and illuminating and making water-proof putties and cements.

Rosin is used in sizing paper, in soap-making, in the manufacture of sealing-wax, for soldering lead and in tinning, and from it is obtained by destructive distillation rosin oil which is used in making lubricants, printing and lithographic inks, paints, etc., and painting beer-kegs Crude turpentine scrape and pitch are also used in many of these manufactures.

The Report of the U. S. Division of Forestry for 1891 describes the pine lands of eastern Texas and western Louisiana as follows:* In the center of the region above the Red river, pine ridges alternate with tracts of oak and hickory. Toward the Red river the forests covering the undulating pine lands remain practically unbroken to the Sabine river. On the east side of the Red river the area is estimated at 1,625,000 acres, extending northward an average distance of fifty-five miles, cutting from 4,000 to 6,000 feet to the acre, with no change in character to Trinity river in Texas. In that State the forests of long-leaf pine cover about 5,000 square miles, merging toward the north into the region of short-leaf, toward the south into vast forests of loblolly pine. The fact that but little tapping for turpentine has been practiced in this region may be of importance from a market point of view.

Forests suitable for the manufacture of turpentine, being subject to a triple destruction, will probably give out some time before those suitable for lumber will. Turpentine orchards of long-leaf pine are destroyed by being lumbered, by natural exhaustion from continued tapping and by fires; and their trunks being weakened by boxes the trees are more liable to blow over by the winds. They are renewed only to an inconsiderable extent by regrowth. The rate of destruction by each of these agencies has been yearly increasing, and has not yet reached its maximum limit.

FUTURE VALUE OF LONG-LEAF PINE FORESTS.

The future value of a forest of long-leaf pine as a source of lumber is based on these facts. Long-leaf pine wood, even after it has been tapped for turpentine, which has no effect on any of the heart wood except to a slight extent those parts immediately in contact with the faces of the boxes, is much stronger than any other of our pines; and it is especially durable in contact with the soil or when exposed to alternating conditions of being wet or dry. As these qualities of the timber become recognized they will much increase the value and use of the wood for purposes where such qualities are requisite. The rapid thinning of the woodlands of the eastern United States will cause an increase each year in the value of all timber near centers of consumption; and there is a constant increase in the value of stumpage as the utilization of the forests proceeds. When once the mass of standing woody material, the uninterrupted accumulations of centuries, is destroyed, the entire country will each year be dependent for wood on what may be called the annual increase in the forests.

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*Annual Report Secretary of Agriculture, 1891, p. 216.

The lands of the greater part of the northeastern States are already in this condition, and those of the southern States, with the exception of the hardwood forests of the Appalachian mountains, are fast being reduced to a similar condition. This second growth forest is producing very largely nonvaluable woods, having been produced by the seed of inferior species left in lumbering as worthless, and only such of these survive as can naturally withstand the repeated burnings to which the woodlands are subjected. Moreover, most of this second growth is very open and thin, caused by fires and other agencies, and the trees from the same causes are often defective. A large part of the land which should be timber land is unproductive waste land, with absolutely no arborescent growth, and the continued violation of all natural laws concerning plant-life prevents the development of such a growth. The demand for wood is yearly increasing and each year the power of the woodlands to supply it is diminishing.

An abundant supply of wood and timber must be an important factor in the future development of eastern, and particularly south-eastern North Carolina, whether that development be an agricultural or manufacturing advancement; but unless there is a more strict observance of the fundamental laws of all plant-life, particularly in respect to the long-leaf pine on the high sandy land, preventing the destruction of the seed and young pines, this section will be in great want of timber at the time when it will need its timber most.

AREA OF WASTE LAND INCREASING.

In conclusion, it can be said that there are now 400,000 acres of waste sandy land in Eastern North Carolina, and that this area is

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constantly increasing. This land is covered only with a low, scrubby growth of sand black-jack oaks and in places has mixed with these oaks scattered long-leaf pines, unfit for lumber and exhausted of turpentine by the continued tapping. Malpractice, especially the custom of firing the barrens and allowing stock full range on them, has never given the long-leaf pine an opportunity to reproduce itself except over very limited areas, and where protected. From this cause this pine, which will always have the highest value, both for its timber and the abundant resin which it contains, is in danger of becoming extinct in North Carolina, and indeed in all the States where it now grows, at least as far as its commercial importance is concerned.

IMPORTANCE OF EARLY ACTION.

If the long-leaf pine which is still standing is allowed to seed these lands, and the seed and young pines protected from destruction, a regrowth can be obtained with comparative ease, but if the long-leaf pines now standing are once destroyed, the securing on these waste lands of a growth of trees which will be of economic importance will be both a difficult and costly undertaking, since this pine is the only tree of value in the arts which naturally grows on these barren lands. It will cost very little more to secure a regrowth than it does to retain the lands in their present impoverished and unproductive state, since taxes and frequently the interest on the original investment must be paid.

The adoption of some general law for these districts, requiring stock, especially swine, to be confined, would be of great help in securing a regrowth, but it would be imperative, at the same time, to prevent any fire from passing through the barrens, since one fire can kill in a few hours a growth of pines several years old. The final value of the growth would depend, too, on fires being kept out even when most of the trees were large enough to be uninjured by burning. By the time such a growth reached maturity or became large enough to furnish timber, all the original forests will have been cut over and the usually thin and scattering regrowth will be called upon to furnish not only most of the fuel, but all lumber and timber required in building and manufacturing.

So great is the annihilation of the primitive forests and so rapidly does the demand for lumber increase from year to year that it is doubtful if the entire forests of the Southern States can last longer than two or three decades. The same is true of the pine forests which can be used for turpentine production. The ruin of these forests will cause a marked rise in the value of all forest products, so that a certain and a higher-priced market can be assured for all future forest material.

CHAPTER III.

THE NAVAL STORE INDUSTRY IN NORTH CAROLINA.

HISTORICAL SKETCH.

IN COLONIAL TIMES.—As early as 1700 the production of naval stores was an industry of some importance in the Colony of Carolina. At the same time the industry was carried on in the adjacent parts of Virginia. In Virginia the products were largely derived from the loblolly pine, while in North Carolina they came chiefly from the long-leaf pine. The products exported from the colony at that date were tar and pitch and some crude turpentine; but the quantity of the latter shipped was small. Tar kilns were made then as now and the process of burning was the same. Indeed, the process is very much the same as that described by Theophrastus as being used by the ancient Greeks.

The *tar* manufactured in the Southern States was more commonly converted into *pitch* before being shipped, by the addition of some crude turpentine and the mixture then being boiled down to the right consistency. From north-eastern North Carolina it was shipped by way of Norfolk, Va., to England, the laws of England at that date forbidding colonial products from being shipped to other than English ports. Until about 1800 the making of tar was not as largely confined to North Carolina as it is at present, nor even to the Southern States. Besides being burnt in Virginia from the loblolly and short-leaf pines, some was made in New York and other Northern States from the pitch pine (*Pinus rigida*), but more for home use than for export. Georgia and South Carolina also produced considerable amounts in colonial days. The method of cutting the boxes for collecting the crude turpentine was then the same as now. The names of some of the parts connected with the process have slightly changed in the meantime. *Cornering* was then called *notching* and the *virgin dip* was called *pure dippings*. These names continued in general use until the early part of the present century.

Both the tar and the crude turpentine produced in the northeastern part of this State were marketed, in the early days, usually in exchange for goods, at Nansemond or Norfolk, Va., and there found ready sale. Before the beginning of the present century both commodities had practically ceased to be produced around Albemarle sound. The seat of the industry slowly moved westward from thence up the Roanoke and Tar rivers and southward, as the settlements extended, to Washington and Newbern, both points shipping large quantities of naval stores to New York and Philadelphia, where it was reshipped to England, and there the crude turpentine was distilled. The largest special use for the crude turpentine in the United States then was for mixing with fats, etc., in making yellow soap.

Later Developments.—Before 1800 Wilmington became one of the largest shipping points for both crude turpentine and tar. In 1804 the exportation of crude turpentine from Wilmington amounted to 77,000 barrels, and the total amount of naval stores shipped exceeded that from all other ports of the United States. The crude turpentine was brought down the rivers on rafts and small boats from as high as Edgecombe county to Washington, from Wayne county to Newbern, and from all the northern tributaries of the Cape Fear river to Wilmington, and was distilled in crude iron stills partly at the shipping points, partly in Philadelphia and New York, and much also went to England to be there distilled. The spirits of turpentine usually found quick sales and good prices except when overproduction took place, and was preferred in France even to the Bordeaux turpentine, which was made in the department of the Landes in Gascony, being less odorous and more uniform in quality than that. The rosin manufactured was worth very little, getting down as low as 25 cents a barrel and then so low it would not pay to handle it. The tar and pitch manufactured at first gave general satisfaction and were made in large quantities. In 1770 there were nearly 100,000 barrels of tar and pitch shipped from the United States, about one-fifth of this amount being pitch shipped from North Carolina.

In 1799 the tar used in England came in equal proportions from Russia, Sweden and the United States. Later the Carolina tar and pitch were less esteemed in England, where they were said to burn the cordage more than the products made in the Baltic provinces. This was said to be due to dead wood being used in North Carolina for making tar and the burning being carried on so rapidly and at so high a temperature that wood acids were formed in large quantities along with the tar. American products were also objected to because they were earthy, the receptacle being carelessly made, and were packed in insecure, leaky barrels. These last objections are sometimes made against them now, though the use of cases for shipping has tended to remedy the evil.

In Bothnia and Sweden, on the other hand, only living wood of the fir and usually from the lower part of the trunk and roots were used and burning was carried on more slowly. In 1831 there were imported into England 10,900 lasts of tar, of 14 barrels each. Of these 8,700 came from Russian provinces on the gulf of Bothnia, 1,200 from Sweden and only 1,000 from the United States. The amount imported from the United States has remained at very near these figures ever since.

The total value of the resinous products shipped from the United States, however, increased from about $200,000 in 1800 to $567,000 in 1834, and to $700,000 in 1838. Most of the products shipped up to this time were from North Carolina, as previous to 1838 trees were not tapped for turpentine south of the Cape Fear river, it being a generally held opinion that south of that river the pines would not yield. This error was soon discovered by experimenting with the trees in that section and orchards there soon became as valuable as those farther north.

In 1836 copper distilleries were introduced in this country and at the same time there was an increased demand for spirits turpentine as a solvent of India rubber, this being the cheapest solvent of that article obtainable, and was thus used in the manufacture of rubber goods.[1] It was also used for illuminating purposes, though the different forms of petroleum oils and the general use in towns of illuminating gas, made from coal, soon supplanted it. Stimulated by this increased demand the production of turpentine extended rapidly southward beyond the Cape Fear river into South Carolina, and up the Cape Fear to Cumberland and Harnett counties. The British free-trade measure in 1846 gave free entrance into English ports to the products manufactured from turpentine and this stimulated the manufacture of these products in North Carolina. From this date forward the exports of crude turpentine decreased as the exports of spirits turpentine, rosin, tar, etc., increased.

It was found more economical to move the stills as close to the seat of production as possible, so that when rosin was low in value the spirits of turpentine only need be shipped. This allowed work to be done farther from the water-courses, near to which the industry had been previously confined. By 1855 about one-half of the spirits of turpentine shipped from Wilmington was distilled inland. The shipments from Washington and Newbern had already begun to decline, the building of the Wilmington and Weldon Railroad having largely turned their trade toward Petersburg and Wilmington.

By 1860 the orchards from which Washington drew its supply approached exhaustion and production soon ceased. Newbern being farther south, the industry continued there for several years longer, but after 1870 the decline in production became rapid and practically ceased during the past decade. There is now no distillery in full operation within thirty miles of Newbern. North of the Neuse river there were in 1893 only eight distilleries in operation, with an output for that year of less than 7,000 barrels of rosin. Three of these distilleries were in Johnston, two in Nash, two in Wilson and one in Wayne county.

SOUTH-WESTWARD EXTENSION OF THE INDUSTRY.—After 1835 the seat of the production of turpentine began to move south-westward through the Southern States. In 1840 the value of the total product amounted to $593,451, nearly the entire amount being produced in North Carolina; and in 1860, while the value of the total product in the United States was $7,454,000, that of North Carolina was $5,355,778. In 1870 North Carolina, with 147 establishments, manufactured naval store products valued at only $2,338,000, while the total product of the United States, with 227 establishments, amounted in value to $3,585,000. In 1893 Georgia made about the same amount of turpentine and rosin that North Carolina did, while Florida, Alabama, Mississippi and Louisiana altogether made about as much more.

The industry has only become of importance in Mississippi and Louisiana during the past few years, and is still capable of great expansion in these States. The turpentine orchards of Georgia are in about the same condition as those in this State, although there is probably in Georgia more round timber standing. The same may be said concerning the forests in Alabama. There are in Texas, however, between 3,000,000 and 4,000,000 acres of untapped long-leaf pine forests and the turpentine industry there has hardly more than made a beginning.

INLAND EXTENSION IN NORTH CAROLINA.—The first turpentine distillery at Fayetteville was established in 1844 by Thomas Lutterlow. The same year the first boxes were cut in what is now Harnett county, near Manchester, by Henry Harrison, who shipped the turpentine from there to Fayetteville to be manufactured. Ten years later there was a distillery owned by Jonathan Worth & Son in operation in the extreme western part of Harnett county near Buffaloe Springs.

The building in 1850 of a plank road from High Point to Fayetteville, which road was followed in a few years by a similar one from Fayetteville through the western section of Cumberland county and another which was projected to Raleigh through Harnett and Wake counties, but only partially finished, caused Fayetteville to become the seat of a large business both in handling turpentine and rosin and in distilling the crude turpentine. The satisfactory prices obtained, and the facility with which the produce could be gotten to Fayetteville on the plank roads for shipment down the Cape Fear river to Wilmington, led to the industry's extending before the outbreak of the civil war, even to the very western limits of the pine belt in Chatham, Wake and Moore counties.

The completion, subsequently, of railroads across the western part of the long-leaf pine belt caused a great deal of the rosin and spirits, manufactured along their lines, to be shipped direct to Northern and other inland consumers, without going *via* Wilmington. In 1893 over 5,000 barrels of rosin went direct west by way of Paint Rock, and over one-half as much went direct north or to Norfolk by rail, as was shipped by way of Wilmington. Although the output of rosin and spirits of turpentine has more than doubled in the United States since 1860, the demand has increased nearly as rapidly until within the last few years, when there has been over-production and consequently low prices.

VALUE OF THE NAVAL STORE PRODUCTS OF THE UNITED STATES.

From the Eleventh Census the total value of the naval stores manufactured in the United States for the year ending May 31, 1890, was $8,077,379. The product that year consisted of 346,524 barrels of spirits of turpentine, 1,429,154 barrels of rosin, and about 40,000 barrels of tar, pitch and miscellaneous products. The turpentine products given above represent the entire amount produced in the world for commercial purposes with the exception of that made in southern France and Austria, which altogether did not amount to 25,000,000 pounds (about 100,000 barrels).

AMOUNT OF CAPITAL AND LABOR EMPLOYED.

The cost of the crude material used to produce the output of naval store products in the United States in 1890 was $2,506,440, and the capital directly invested in the manufacture of naval stores in the United States was reported by the Eleventh Census to be $1,117,265, and in North Carolina $269,341. This capital, representing 670 establishments, employed 15,313 laborers in the United States and 1,747 laborers, on an average, in North Carolina, where there were reported to be 194 establishments.

The relatively small number of laborers given as employed in this State is due to the fact that the greater part of the turpentine is collected by farmers (or their "hands") who have a small area of turpentine orchard and utilize their time at dull seasons in this way; and many of these are not included in the above estimate. But some of the turpentine collected in other States is also gotten in the same manner.

CONDITION OF THE NAVAL STORE INDUSTRY IN NORTH CAROLINA.

During the latter part of 1893 the Geological Survey made an examination into the condition of the naval store industry in North

Carolina, and particularly into the condition of the turpentine orchards and the prospects of this industry in the State. The statistics for 1893 relating to this industry, which are given below, have been secured by correspondence with naval store dealers and distillers in all parts of the long-leaf pine region and by personal visits to many sections. The figures used in comparisons have been derived from the latest U. S. Census reports, unless credited to other sources.

SPIRITS TURPENTINE AND ROSIN STATISTICS.

The accompanying table shows for the year ending December 31, 1893, the number of turpentine distilleries in operation during the year, and the amounts of rosin and turpentine manufactured in each county, together with the amounts shipped from each county to Wilmington, N. C., and the amounts shipped direct by rail routes to consumers and dealers elsewhere.

Yield of Rosin and Spirits Turpentine in North Carolina, 1893.

County.	Number of Distilleries.	Rosin Manufactured.			Spirits of Turpentine Manufactured.		
		Barrels shipped to Wilmington.	Barrels shipped by rail elsewhere.	Total number of barrels.	Casks shipped to Wilmington.	Casks ship'd by rail elsewhere.	Total Number of casks.
Bladen..............	27	39,800	3,600	43,400	7,500	990	8,490
Brunswick	8	12,000	....	12,000	2,800	....	2,800
Columbus	26	37,200	....	37,200	7,750	....	7,750
Cumberland	24	21,000	15,000	36,000	3,200	3,961	7,161
Duplin..............	5	7,800	....	7,800	1,060	....	1,060
Harnett	9	3,700	9,050	12,750	400	2,335	2,735
Johnston...........	10	....	16,764	16,764	....	2,632	2,632
Montgomery......	12	....	22,000	22,000	....	5,150	5,150
Moore..............	34	3,125	38,207	41,332	200	8,637	8,837
Onslow..............	12	12,600	2,700	15,300	2,700	450	3,150
Pender..............	8	10,400	....	10,400	2,060	....	2,060
Richmond..........	13	7,170	6,017	13,187	1,800	1,083	2,883
Robeson	28	30,200	9,910	40,110	4,712	3,233	7,945
Sampson	30	41,000	3,000	44,000	7,920	2,121	10,041
Wayne..............	3	....	3,970	3,970	....	517	517
*Other counties..	7	4,000	7,768	11,768	800	1,517	2,317
Totals...........	256	229,995	137,986	367,981	42,902	32,626	75,528

*This includes four counties: Nash with 2 distilleries, Wilson with 2, Lenoir with 2 and New Hanover with 1. The amounts included in this statement for New Hanover county are estimates obtained by adding the average yearly output of one distillery.

The number of counties which produced crude turpentine during the year (1893) was 19. The amounts produced in New Hanover, Nash and Wilson were very small, New Hanover producing practically none. The greater part of the crude turpentine which was manufactured in that county was brought from South Carolina, and from inland counties along the Cape Fear and Northeast Cape Fear rivers.

The total amounts of rosin and spirits of turpentine manufactured in North Carolina and their values are shown in the accompanying table for the year 1893 and the census years ending May 31, 1870, 1880 and 1890 as reported by the United States Census for those years.

Quantity and Value of Rosin and Spirits Turpentine Manufactured in North Carolina.

YEAR.	Number of establishments.	ROSIN.		SPIRITS OF TURPENTINE.		Total value.
		Barrels.	Value.	Casks.	Value.	
1870	147	....	....	....	....	$2,338,309
1880	184	....	....	....	....	1,758,488
1890	194	365,233	$377,310	72,888	$1,293,086	1,705,833
1893	247	367,981	392,000	75,528	1,283,760	1,752,760

The total values represent the value of all products manufactured directly from turpentine.

Production has ceased during the past ten years in Wake, Craven and Edgecombe counties. There has been an increase since 1880 only in Moore and Montgomery counties, the number of barrels of rosin produced in Moore county for the year (1893) being considerably larger than the number produced in 1880, though the value of the product is less now than at that date. Montgomery county is credited with no resinous products in the census of 1880, but in 1893 there were 12 distilleries operating there which produced 22,000 barrels of rosin.

DECREASE IN THE PRODUCTION OF CRUDE TURPENTINE.

The quantity of crude turpentine shipped is small now compared with past shipments. All that was shipped last year went direct to domestic consumers, mostly manufacturers of printing and lithographic inks. Boston was the largest market, New York and Baltimore being next in order. There were 6,331 barrels shipped from Wilmington and 4,600 barrels from other points, making a total of 10,931 barrels, with an estimated valuation of $12,000. The grades of this crude turpentine were not obtainable.

The general decrease in the amount of crude turpentine produced in the extreme eastern counties during the past twenty years is approximately shown by the decrease in the exports of rosin and spirits turpentine from Wilmington. This will not apply to the more westerly counties and to Harnett, Johnston, Cumberland and Robeson, since additional railroad facilities during the past ten years have turned a large part of their products from Wilmington. In a few of these counties, as in Montgomery and Moore, the product has increased considerably of late, owing to better railroad facilities, but this product is largely transported direct to Northern markets and does not enter into this statement of exports from Wilmington.

The total exports of rosin and spirits of turpentine from Wilmington for every year since 1872, as shown by the records of the Wilmington Produce Exchange, were as follows:

Total Rosin and Spirits Turpentine Exported from Wilmington, 1873–'93.

YEAR	Exports of Rosin, Barrels.	Exports of Spirits of Turpentine, Casks.	YEAR.	Exports of Rosin, Barrels.	Exports of Spirits of Turpentine, Casks.
1873	690,151	131,236	1884	342,936	71,354
1874	556,182	125,837	1885	314,724	66,603
1875	523,330	107,420	1886	331,497	63,684
1876	490,555	91,592	1887	381,535	71,912
1877	537,704	101,832	1888	246,566	63,473
1878	581,958	118,176	1889	351,827	61,626
1879	512,891	91,224	1890	385,523	70,285
1880	447,750	101,725	1891	304,818	60,844
1881	486,138	87,658	1892	273,291	58,034
1882	444,318	87,896	1893	224,070	47,228
1883	453,465	82,135			

When the exports of 1883, for both rosin and spirits of turpentine, are compared with those of 1873 there is shown a falling off of over one-third, while there is a falling off of nearly one-half in the decade between 1883 and 1893.

Many distilleries in the extreme eastern counties reported that their territory had not been thoroughly worked, during the last few years, on account of the low prices, and that any rise in prices would largely increase production. This fact may in part account for the more rapid decline in the receipts of rosin and spirits of turpentine at Wilmington since 1883.

The following table gives the foreign exports of rosin and spirits of turpentine from Wilmington and their value for the past ten years. The data were kindly compiled from the records of the custom-house at Wilmington, for the Survey, by Mr. J. M. Cronly, Deputy Collector of that port:

Quantity and Value of Foreign Exports of Rosin and Spirits Turpentine from Wilmington, N. C., 1874 and 1884-'93.

Year.	Foreign Exports of Rosin.		Foreign Exports Spirits Turpentine.	
	Barrels.	Value	Gallons.	Value.
1874	248,424	$..................	2,530,000	$..................
1884	300,932	405,776	1,418,848	470,644
1885	290,165	348,849	2,375,482	689,964
1886	288,499	306,538	2,139,091	732,642
1887	333,119	338,356	2,203,457	757,398
1888	311,613	341,825	1,988,103	695,476
1889	281,251	296,987	1,630,795	641,025
1890	302,094	394,569	1,751,270	709,988
1891	296,918	426,007	1,473,157	565,834
1892	251,853	271,394	1,080,231	372,534
1893	231,056	299,286	918,727	256,178

While the foreign exports of rosin have varied but little there has been a steady decline in the amount of spirits of turpentine shipped.

THE ROSIN TRADE.

The bulk of the rosin made in the United States is used in foreign countries, England importing the larger part of it. About two-thirds of the amount manufactured in North Carolina last year went to Europe, and the remainder to domestic consumers. Domestic manufacturers use more of the fine grades of rosin made in this State than foreign manufacturers do. An attempt was made to ascertain the amounts of the different grades of rosin manufactured, but returns as to this point were frequently imperfect. There were, however, about 4,800 barrels of W. W. and W. G. rosin (the two highest and lightest colored grades)* shipped by rail from the western counties of the pine belt, and about 4,000 barrels of the same grades were shipped to Wilmington, from the more eastern counties of the pine belt. There were about 20,000 barrels of other grades of light rosin (above N.) made in the western counties, and shipped by rail, and about 25,000 barrels of these grades made in the more eastern counties and shipped *via* Wilmington. It seems that, while Wilmington handled nearly two-thirds of the rosin manufactured in North Carolina it only received about one-half of the finer grades of rosin. Practically all of the finer grades of rosin which were received at Wilmington, during the year 1893, were sent to Europe.

EXPORTS OF TAR AND PITCH FROM NORTH CAROLINA.

Exports of tar and pitch from North Carolina have varied during the past twenty years much less than have those of rosin and turpentine. The exports, both foreign and domestic, of these commodities from Wilmington for the years 1874, 1884 and 1893 were as follows:

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*GRADES OF ROSIN.—The commonly recognized grades of rosin in the United States are as follows: "W. W."—water white; "W. G."—window-glass; "N."—extra pale; "M."—pale; "K."—low pale; "I."—good No. 1; "H."—No. 1; "F."—good No. 2; "E."—No. 2; "D."—good strain; "C."—strain; "B."—common strain; "A."—black.

"Water white" and "window-glass," which are the lightest colored and highest priced rosins, are made only from the "virgin dip," and usually only from that gathered during the first parts of the season. The virgin dip is the turpentine taken from the boxes the year or season that they are cut. The last dipping of the first season (the boxes are dipped from six to eight times during a season) give a yellowish turpentine which makes rosin of about the grade "N." The second and succeeding years "yellow dip" is obtained, the turpentine having acquired a decided yellow tinge of color from running down over the face of the tree which was hacked during the preceding summer when it comes in contact with the old and dark-colored resin on its surface, and is subject to the evaporation of the volatile oils in it by being longer exposed to the heat of the sun.

The second year's yellow dip makes usually rosin of the grade "N." during the first part of the season, while only darker grades "L." and "M." are gotten during the latter part of the season. Each year that the boxes are worked the dip becomes more colored, yields a darker rosin, and has less spirits of turpentine in it on account of having to run down a larger surface, covered with colored resin, and be exposed for a longer time to the oxidizing influences of the sun and air. The "scrape," which is the hardened resin adhering to the scarified face of the tree, yields the darker grades of rosin. The common grades are made from old scrape on trees which have been worked several years, and frequently has mixed with it sticks and chips, cut from the tree while the hardened scrape was being removed. The turpentine produced from the lighter colored dippings is of a better quality than that from the darker, being purer and lighter and having less rosin oil in it.

A large part of the dark grades of rosin ("strain" and "common") which are exported to Europe are used in manufacturing rosin oil. The finer grades are used in the manufacture of soaps, paper sizing, etc.

Total Exports of Tar and Pitch from Wilmington.

YEAR.	Tar, Barrels.	Pitch, Barrels.
1874	68,619	7,400
1884	68,794	5,734
1893	52,541	3,274

In 1893, besides the above, 4,600 barrels of tar and 700 barrels of pitch were shipped North by rail from Robeson and Cumberland counties. This makes a total of 57,100 barrels of tar and 4,000 barrels of pitch, with an estimated value of $65,000. The foreign exports of tar and pitch from Wilmington, for the years 1873, 1884, 1893 were as follows: In 1873 they were 48,200 barrels; in 1884 they were 20,138 barrels; in 1893, 7,740 barrels. This shows a decline in the foreign exports of more than 50 per cent. during each decade.

TOTAL AMOUNT AND VALUE OF NAVAL STORE PRODUCTS IN NORTH CAROLINA, 1893.

The total amount and value of the naval store products shipped from North Carolina during the year 1893 were approximately as follows:

Amount and Value of North Carolina Naval Store Products, 1893.

75,528 barrels of spirits turpentine	$1,283,760
367,981 barrels of rosin	392,000
10,931 barrels crude turpentine	12,000
63,100 barrels tar and pitch	65,000
Total value of products	$1,752,760

A preliminary report of the Eleventh Census estimates the total products for North Carolina for the year ending May 31, 1890, to have had a valuation of $1,705,833. No crude turpentine is given in that report and the tar is given at 600 barrels, valued at $847 for the entire State. This statement is evidently incorrect, since the exports of that product from Wilmington alone amounted to

72,000 barrels for the year 1890 and almost as much for the preceding year.

CONDITION OF THE TURPENTINE ORCHARDS IN NORTH CAROLINA.

As bearing on the future supply of resinous products in North Carolina, a close examination was made into the condition of the long-leaf pine forests now standing in the State, and in the following notes the writer has endeavored to show the character and extent of the existing productive orchards, of those orchards which have been abandoned, the round timber which can be boxed, and the second growth long-leaf pine.

LENGTH OF TIME THAT TURPENTINE ORCHARDS ARE WORKED.

The orchards of the Cape Fear river section have been worked steadily for from twenty to thirty-five years and in Sampson and Bladen counties many bodies of pine are reported as having three sets of boxes on them, having been worked since 1845, with intermissions of a few years for rest and to allow the space between the hacked faces to increase in breadth. The yield from these long-worked trees is still considerable when they grow on good soil, and when the trees have been injured in no other way, as by fire charring the faces of the old boxes.

These trees along the Cape Fear river seem capable of standing continuous working longer than those in any other part of the State or even of the United States, there being numerous reports from this section stating that the orchards had been worked from forty to fifty years. From Columbus county only one distiller reported that his trees had been worked as long as thirty-five years, while others stated that theirs were abandoned after having been worked from twenty to twenty-five years. One distiller in Robeson county, on the Cape Fear river, reported fifty years as the maximum time, while for those farther west, in Moore county, approaching the clay uplands and at an elevation of from 300 to 500 feet above the sea-level, a productive limit of twenty years was given. In South Carolina the trees are worked from twelve to fifteen years; in Georgia from four to eight years, except the slash pine (*Pinus* *cubensis* Griseb.) along the coast, which "runs dry" in one or two years, as is true of the loblolly pine in North Carolina.

It may be said that most of the orchards now producing in North Carolina have been "back-boxed"* and that over four-fifths of the crude turpentine comes from back-boxed trees. Only in Montgomery and the western parts of Moore county are there any extensive bodies of trees which have not been back-boxed. The average time the trees have been worked in these two counties is about seven years, but many of the orchards in Montgomery have only been worked for four years.

AREAS OF ABANDONED TURPENTINE ORCHARDS.

An examination of this region showed that large areas of long-leaf pine forests had been abandoned as no longer profitably yielding turpentine. Such areas, where the trees are still standing, are classed by the distillers as *abandoned orchards*. When these forests have been removed by fire or cut by lumbermen and no loblolly pine has appeared to take the place of the long-leaf pine, the term *waste land* is applied to these areas. The following estimates of the amounts of abandoned orchards in the separate counties are based on returns made by 162 distillers in these counties, supplemented by personal investigation by the writer. These areas, in acres, of abandoned turpentine orchards were as follows in December, 1893:

Areas of Abandoned Turpentine Orchards in North Carolina, 1893.

Bladen county	60,000	acres.	Onslow county	38,000	acres.
Brunswick	98,000	"	Pender	28,000	"
Cumberland	51,000	"	Richmond	32,000	"
Duplin	17,000	"	Robeson	63,500	"
Harnett	52,000	"	Sampson	58,500	"
Lenoir	20,000	"	Wayne	30,000	"
Johnston	30,000	"	Wilson	20,000	"
Montgomery	10,000	"	Other counties	75,000	"
Moore	10,000	"		———	
Nash	25,000	"	Total in the State	718,000	"

Included in the term "other counties" are Wake, Edgecombe, Craven, Columbus, New Hanover and Carteret counties. The amount abandoned during the past few years has been greater than usual, the very low prices making it unprofitable to work thinly timbered orchards longer. The operation of many of these bodies may be resumed should there be any material advance in prices of naval store products, but such a change is hardly probable. In these areas of abandoned orchards there is a great range of density of forest growth, varying from that which may be called the normal density, which will cut from 3,500 to 4,500 feet, board measure, to the acre, to that which will scarcely cut 300 feet to the acre, below which latter limit it would be considered *waste land* unless a growth of loblolly pine has, in part, replaced the long-leaf pine. Although there is very little of this abandoned orchard that is heavily timbered with long-leaf pine, all of it has, more or less, valuable mill timber on it. Much of the timber might again be boxed and profitably worked if protected until the growth of the space between the boxes would allow new boxes to be cut.

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*For explanations of this and other terms see pp. 94—96.

ANNUAL ADDITIONS TO THE TURPENTINE ORCHARDS.

The number of acres of round timber being boxed yearly is now very small. An attempt was made to ascertain this amount, but both *back boxes* and *original boxes* were included in the returns; these figures, too, were somewhat fragmentary for certain districts. For the seasons 1892–'93 and 1893–'94 the *total number of boxes* cut in each county were about as follows:

Number of Boxes Cut in North Carolina, 1892–'94.

COUNTY.	Season 1892–'93.	Season 1893–'94.	COUNTY.	Season 1892–'93.	Season 1893–'94.
Bladen	86,000	95,000	Nash	60,000	60,000
Brunswick†	10,000	....	New Hanover*	....	....
Columbus	60,000	70,000	Pender	33,000	22,000
Cumberland	255,000	220,000	Onslow	35,000	18,000
Duplin†	11,000	4,000	Richmond	90,000	65,000
Harnett	82,000	70,000	Robeson	197,000	96,500
Johnston	35,000	42,000	Sampson	114,000	105,000
Montgomery	35,000	60,000	Wayne	7,000	3,000
Moore	83,000	78,000	Wilson	....	....
Lenoir†	....	3,000			
			Totals	1,193,000	1,011,500

*No returns made. †Returns not full.

It can be roughly estimated that it would require the trees on 20,000 acres to hold the number of boxes cut in 1893–'94. The proportion of this which was round timber, and which represents the increase in the area of orchard, was under 3,000 acres. The largest single tract ascertained to have been newly boxed was 350 acres in Bladen county. There were other tracts nearly as large in Sampson, Harnett, Richmond and Montgomery counties.

BOXING OF OTHER SPECIES OF PINES.

The loblolly and short-leaf pines are not generally tapped in this State. An attempt was made, however, to find out the number of loblolly pine (*P. Taeda*) boxes cut last year in Johnston and Robeson counties, where most of them are worked, and the number was found to be under 20,000, showing that a very insignificant amount of turpentine is produced from this tree. There were about 3,000 short-leaf pine (*P. mitis*) boxes cut last year in Montgomery county. This tree was extensively worked fifteen years ago in Wake and Chatham counties. The young trees are the only ones which yield sufficiently to justify boxing; they yield about two-thirds as much crude turpentine as the long-leaf pine and can be worked from six to seven years. The crude turpentine from the loblolly pine is very thin, and runs so freely that it usually overflows the box and runs down to the ground, unless the boxes are dipped more frequently than the long-leaf pine boxes are. It is said to have so much water in it that when distilled without a large intermixture of crude turpentine from the long-leaf pine only a poor quality of spirits turpentine is obtained.

AMOUNT OF ROUND TIMBER AVAILABLE FOR BOXING.

This name is given to the original growth of long-leaf pine before it has been boxed. It makes, of course, better mill timber than the boxed trees, which have the lower part of the stock around the face of the boxes surcharged with resin, obliterating all signs of the grain and making what is called lightwood. The amount of round timber, in acres, standing in each county December, 1893, was, as nearly as could be determined, as follows:

Amount of Round Timber (Long-leaf Pine) in North Carolina, December, 1893.

Bladen	3,900 acres.	Nash	700 acres.
Columbus	3,700 "	Onslow	3,200 "
Cumberland	1,300 "	Pender	5,400 "
Duplin	1,900 "	Richmond	2,200 "
Harnett	6,100 "	Robeson	6,850 "
Johnston	200 "	Sampson	876 "
Jones	400 "	Wake	700 "
Lenoir	1,500 "	Wayne	200 "
Montgomery	6,050 "		
Moore	10,700 "	Total for the State	55,876 "

The total amount of round timber now standing is very little more than was yearly being put in orchard during the period between 1840 and 1870. The number of acres of round timber standing in these same counties fifty years ago must have been between 4,000,000 and 5,000,000 acres. Much of this remaining timber will probably never be boxed, being in small bodies in districts where trees have ceased to be worked for turpentine.

YOUNG GROWTH OF LONG-LEAF PINE.

The young growth of long-leaf pine may also be included along with the round pine as timber which in part now, or in the near future, can be worked for turpentine. But unfortunately the acreage of second growth pine which is now, or even soon will be, of sufficient size to be boxed for this purpose, is very small, and the trees in such growth are scattering, consequently they are short-bodied and present little uniformity as regards size or regularity of growth. The figures for this acreage are based on field notes taken during an examination of the pine lands during the winter of 1893–'94. In each case they are probably much in excess of the true amount of young growth of trees large enough to hold a turpentine box. The counties in which any large amount of young growth was observed and the approximate amounts of this in each (in acres) are enumerated in the accompanying table:

Areas of Young Growth of Long-leaf Pine in North Carolina, 1893.

Bladen county	3,500 acres.	New Hanover	4,000 acres.
Craven	5,000 "	Robeson	2,000 "
Cumberland	2,700 "	Sampson	2,500 "
Moore	700 "	Others possibly	10,000 "
Lenoir	2,000 "		
Johnston	700 "	Total in the State	33,100 "

Some of this young growth has already been boxed, but the amount of turpentine gotten from it is inconsiderable. It varies in age from about eighteen to thirty-five years, and in diameter from four inches to eighteen inches. The amount of young growth loblolly and short-leaf pine is very large, should the price ever allow them to be extensively worked for turpentine.

DECREASING AREA OF TURPENTINE ORCHARDS IN NORTH CAROLINA.

As shown in the above statements the additions to the areas of turpentine orchards during the past few years, from both the taking in of new mature forests and the boxing of young or second growth pine trees has been small. On the other hand, the destructive agencies, such as forest fires, storms and the lumbermen, have been actively at work, and as the result of their combined activities the area of productive turpentine orchards in North Carolina has been reduced to but a small part of what it was half a century ago. Over the large areas north of Neuse river the long-leaf pine has practically disappeared. Over large areas between this river and the South Carolina State boundary line many of the once dense virgin long-leaf pine forests have given place to equally large areas of abandoned pine barrens and waste lands.

DESTRUCTION OF ORCHARDS BY FIRES.

Every year there is more or less destruction of standing timber by fires, both in worked and in abandoned orchards. The loss during the past year and the number of acres burnt over are shown with approximate accuracy in the accompanying tabulated statement:

Some of the Losses from Fires in Long-leaf Pine Forests, 1893.

LOCALITY.	No. of Acres Burnt.	Loss.
Moore county	30,000	$25,000*
Cumberland	10,000	12,000†
Robeson	5,000	6,000
Six other smaller fires	3,500	5,000
Totals	48,500	$48,000

*Estimated by W. E. Petty, Esq., Carthage, N. C.

†Estimated by Mr. John Blue, of Aberdeen, N. C.

All of these fires took place in the spring, either in March or April, and all were reported as started from the firing of the grass of the pine barrens. The first two fires were particularly severe, going through orchards that were being worked, and ruining not only the boxes, but also killing a great deal of the timber, very little of which was so situated that it could be converted into lumber before being attacked by the borers.

In the fall of 1892 there was another severe fire in Richmond and Moore counties, which destroyed a large amount of timber, and also the village of West End, on the Aberdeen & West End Railroad. The value of the timber alone destroyed by this fire was placed at $75,000.

The danger and loss occasioned by fires in the forests is not sufficiently understood by the class of persons who are generally the cause of them. In the pine barrens most of the fires are purposely started, and the persons starting them should be held responsible for any loss caused by them. Too great discretion cannot be exercised about a suitable time to burn the woods, when it is deemed absolutely necessary to burn them, and persons should be careful that it is not too late in the season: after the trees have begun to put forth their leaves or shoots, and that the season is not too dry. Much care should be taken to prevent such fires escaping proper bounds and destroying the property of other persons who are in no way connected with the starting of the fire.

The damage of fires is more than local and the loss occasioned by them, or resulting from them, is felt far beyond the immediate district in which they occur. Even when there is no apparent damage it sets a precedent, the following of which is sure ultimately to lead to great damage. And there is always a considerable amount of damage done; enough to far more than counterbalance the advantages supposed to be gained in improving the pasturage of the forests or in other ways.

The illustration (Plate I) facing page 58 is from a photograph of a long-leaf pine forest a few miles west of Southern Pines, Moore county, taken some months after a forest fire had swept through this region. All of the pines at this point were killed. Many of them fell and were partially or completely destroyed, and the few left standing were practically ruined, as they could not be cut at once. (See, also, pp. 57 and 61 for notes on the destructive work of forest fires).

DAMAGES TO ORCHARDS FROM STORMS.

Besides the injuries to turpentine orchards, during 1893, from fires they were damaged by two severe storms, occurring one in August and the other in October, in the fall. The earlier storm, in August, did but slight damage, except to abandoned orchards. The one of October 14th, however, proved generally destructive to all boxed pines, besides blowing up by the roots many oaks and other hardwood trees. The damages were greater in the south-eastern portions of the State, especially in Columbus, Bladen, Sampson and Johnston counties, but they were by no means confined to these counties. The force of the storm was not uniformly distributed over this area, but was more severe at numerous scattered points. Twenty distillers in these counties estimate that at least one-tenth of their trees were blown down, while other orchards were injured to a less extent, and several thousand acres of abandoned orchard were ruined.

Most of this fallen timber proved to be a total loss, though about 100,000 railroad cross-ties were cut from it at points contiguous to the railroads, and small quantities of it were carried to the saw-mills on the Cape Fear river. Unboxed long-leaf pines suffered very little, and neither the loblolly pine nor swamp timber was damaged to any considerable extent. Boxed pines, as a rule, were broken off at the box. Out of one hundred prostrated long-leaf pines seen near Bladenboro (N. C.) eighty-five were broken off at the *box*, four above the box but along the *face*, ten were blown up by the roots, and only one tree was broken off above the face of the box. These facts show the importance of adopting some other system of gathering the turpentine which will avoid the deep boxing of the trees. Such a system is practiced in France, and is described further on in this report (page 96).

AREA OF ORCHARDS REDUCED BY LUMBERING.

Lumbermen are also instrumental to a considerable extent in reducing the acreage of turpentine orchards. In Moore, Richmond and Robeson counties they are rapidly cutting into the orchards. Eleven distillers in the two first counties reported their orchards as having been cut into by lumbermen last year. At least 35,000 acres of new and abandoned orchard must have been cut over during 1893 to have yielded the lumber cut during that year by the mills sawing long-leaf pine.

HOW LONG CAN OUR TURPENTINE ORCHARDS LAST?

It appears from the foregoing that there are in the State less than 75,000 acres of long-leaf pine timber now unboxed which can be added in the future to the turpentine orchards, and that the present yield of turpentine is derived principally from "back-boxed" trees, which if not destroyed within twenty years could not continue to yield turpentine for more than that length of time. In point of fact, however, the trees of existing orchards cannot produce turpentine, except in a small way, for even that length of time, since they are being destroyed by fire, or converted into lumber, at the rate of over 60,000 acres a year. Then, too, the rate of destruction increases each year as the number of mills increases, and as the amount of abandoned orchard, which proper precautions are not taken to protect from fire, becomes larger; and these abandoned orchards serve as means of carrying fire to the newer orchards which are being used.

FRENCH AND AMERICAN METHODS OF GATHERING TURPENTINE.

The two chief objections to the American system of boxing trees for turpentine are:

(1). The injury to the tree produced by the box, interrupting and impairing the life processes and sooner or later damaging the timber or causing its entire destruction, and,

(2). That the yield of spirits of turpentine is less than it should be, and the rosin manufactured is largely of darker and inferior grades.

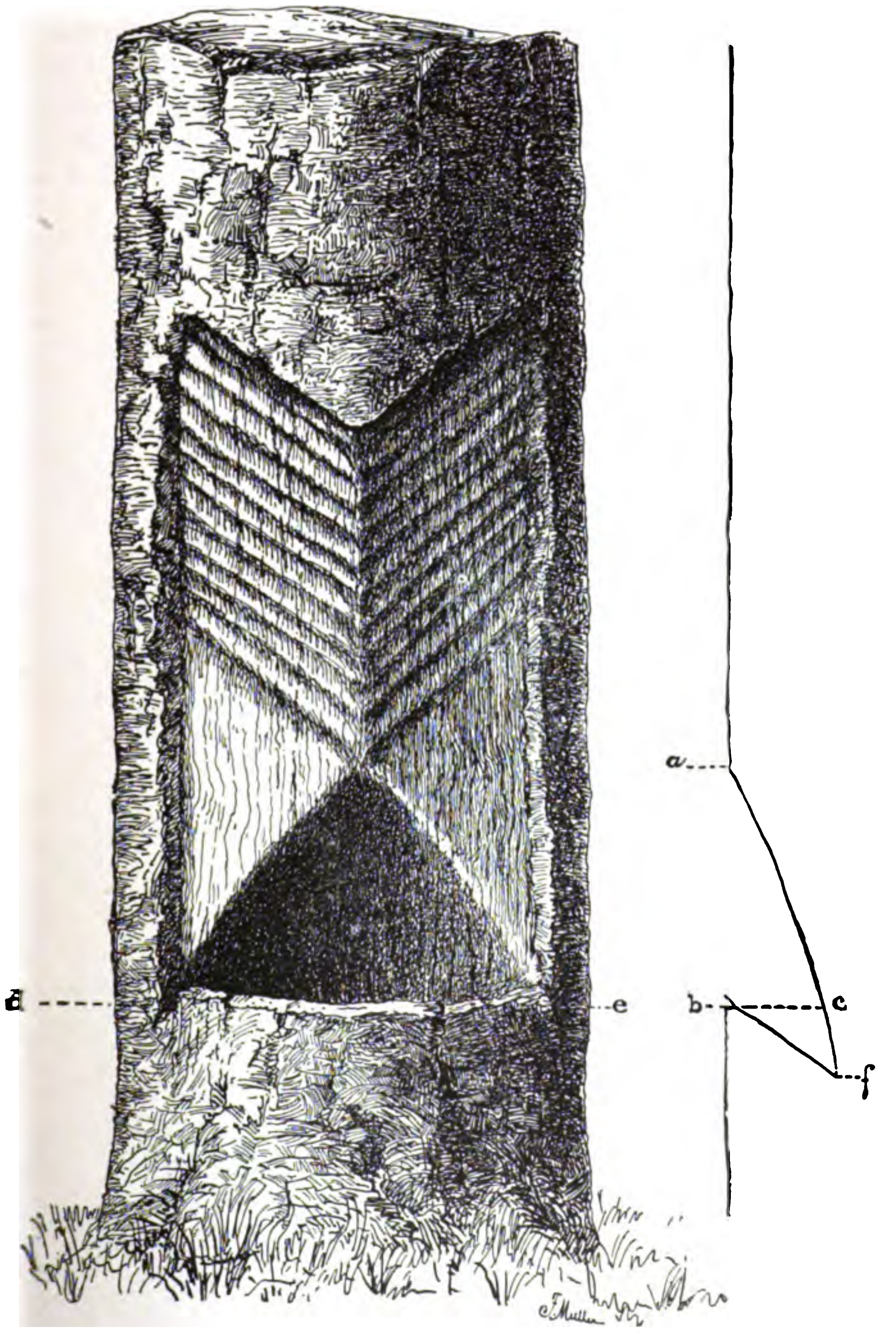
A method of tapping the trees, which to a very great extent remedies these faults, is the Hugues system, which was first used in France about 1860, and since that time has come into general use in that country, having been found more efficacious than the one previously used there. It presents as great an advancement on the American system now in vogue as the American did on the early French method.

THE AMERICAN SYSTEM OF GATHERING TURPENTINE.

The American method, which can be advantageously used only on stocks over fifteen inches in diameter, consists of cutting in the base of the tree, about eight inches from the ground, a hole called the *box.* This box, which is hollowed out with a narrow, thin-bladed axe manufactured for the purpose, has a length following the circumference of the tree of about fourteen inches (*d* to *e* of Plate II), a depth of about seven inches (*b* to *f*), and extends back into the wood at the mouth of the box about four inches (*b* to *c*), or at the bottom of the box (*f*) about five inches. At the same time that the box is cut there is a triangular strip removed on either side of it and extending up as high as the tip of the box. This operation is called *cornering* and the channels left where the chips were removed act as gutters leading into the box.

Immediately above this box the thin bark and a thin section of the sap-wood is removed by means of a sharp, bent-bladed implement called the *hack.* In this process, called *hacking* or *chipping,* the implement is drawn at an oblique angle across the surface of the trunk alternately in opposite directions, each pair of grooves made by the hack forming a V, so that the cut surface consists of two planes forming a very obtuse angle, the lines of their union running vertically up the tree above the center of the box, and down which line the resin runs into the box. This scarified surface, called the *face,* has a breadth of from fourteen to sixteen inches and a depth usually of one and one-half to two inches, rarely going in as deep as the thickness of the sap-wood.

The boxes are cut late in fall or early in spring, and in the first part of March chipping is begun, and is repeated about once a week for from thirty to thirty-five weeks, according to the



AMERICAN PRACTICE OF BOXING AND CHIPPING.
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length of the summer season and the way the resin runs. At each chipping about one-half an inch of wood is cut off. The resin lying in the resin ducts or pores, which are parallel with the grain of the wood, flows out when these ducts are cut and runs down into the box. The object of repeated chipping is to open a fresh surface for the exudation, when the ducts have become clogged by an accumulation in them of hardened resin. By the end of the first season the face has been carried up eighteen to twenty four inches above the box.

The resin which runs into the box, called *virgin dip* the first season, and the *yellow dip* of subsequent years is a thick, viscid liquid, more or less transparent and thinner the first season, but hardening quickly on exposure. During the first season it is removed seven or eight times from the box. That resin which hardens on the face is removed by a sharp *scraper* (*scraping*) and is mixed with chips and bark, and, besides containing only one-half as much spirits of turpentine as the dip, makes a much harder and darker and withal less valuable grade of rosin than the dip, much of the spirits of the scrape having evaporated or oxidized under the influence of light, heat and air. Each year as the face is carried up higher, about twenty inches a year, there is more scrape and less dip, as the resin exuding from the freshly hacked surface has to run over the entire surface which has already been hacked before it reaches the box, and a large proportion of it hardens and never reaches the box.

The *dip*, as has been explained, becomes, in succeeding years, gradually darker as work is carried on until it makes only a slightly better rosin than the scrape and contains only two-thirds as much spirits of turpentine as the virgin dip gotten the first year the boxes were worked. There will average two such boxes to a tree, the trees generally being about twenty inches in diameter. After the "faces" have been carried up so high that it is no longer profitable to work them, the trees are allowed to rest for several years and recuperate. During this time the sound wood left between the "faces" broadens, partly covering the old faces, so that on large trees new "boxes" can be cut in between the old ones and the trees again worked. This is called "back-boxing." There are frequently three sets of boxes put on one tree.

THE FRENCH SYSTEM OF GATHERING TURPENTINE.

The original French method merely removed the bark and a thin layer of sap-wood from a space (face) about five inches wide on each tree, and the resin as it exuded after the repeated chippings ran into a receptacle placed at the foot of the tree to receive it, or frequently into a hole dug in the sand. By the latter method, which was very primitive, the turpentine was mixed with sand, the spirits was absorbed and only a poor grade of rosin was made from it.

The method adopted in 1860, when the production of turpentine was stimulated in France owing to the stoppage of American exports by the blockades during the civil war, was very much in advance of this. The new method, then adopted, may be described in general terms as follows: At the end of February the outer bark for a considerable height is removed on all trees which are to be tapped that year, leaving only a thin layer of bark over the sap-wood. This is to prevent loose bark from falling into the resin. At the first of March, with a peculiar-shaped implement resembling an adze with a bent handle and a curved blade, there is made near the foot of the tree an incision which is four inches broad, two inches high and only one-third of an inch deep. At the bottom of this incision a curved gutter of zinc or galvanized iron, which has a width of the hacked face and teeth on its inner edge, is driven into the wood. This gutter turns the more liquid resin, which flows down into an earthenware or zinc cup hung on a staple immediately below the gutter.

The accompanying illustration (Plate III), taken originally from Professor L. Boppe's work on Forest Technology, but here reproduced from the Annual Report of the Chief of the Division of Forestry, U. S. Department of Agriculture, for 1892, "represents a pine two hundred years old, with more than fifty scars or chips, without apparently any ill effects on the life of the tree."* Some

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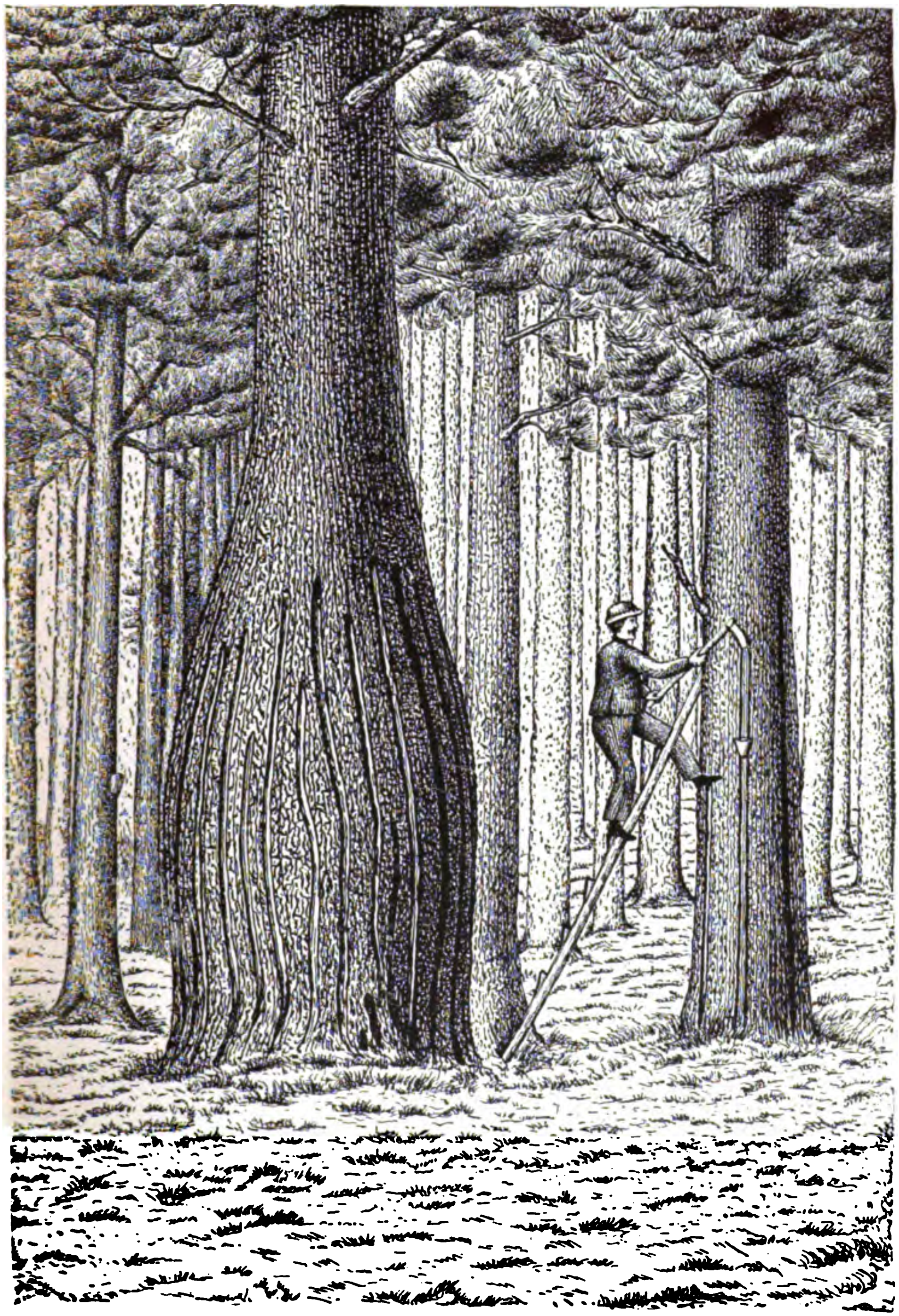
*An. Rept. Secretary of Agr., Washington, 1892, p. 348.



TURPENTINE ORCHARDING IN FRANCE.

[FROM THE U. S. DEPT. AGR. REPT.]

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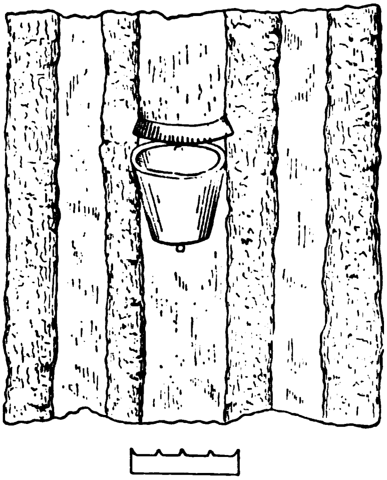

FIG. 1.—TURPENTINE GATHERING (FRENCH SYSTEM), TILL AND POT.

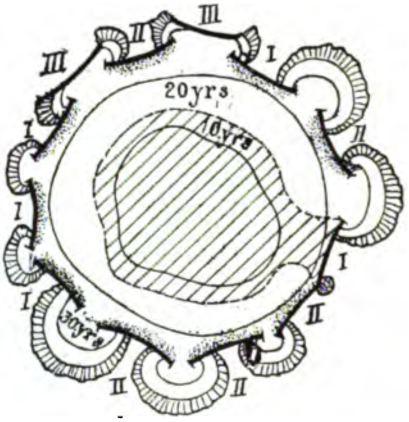

FIG. 2.—CROSS SECTION OF TURPENTINE TREE (FRENCH SYSTEM).

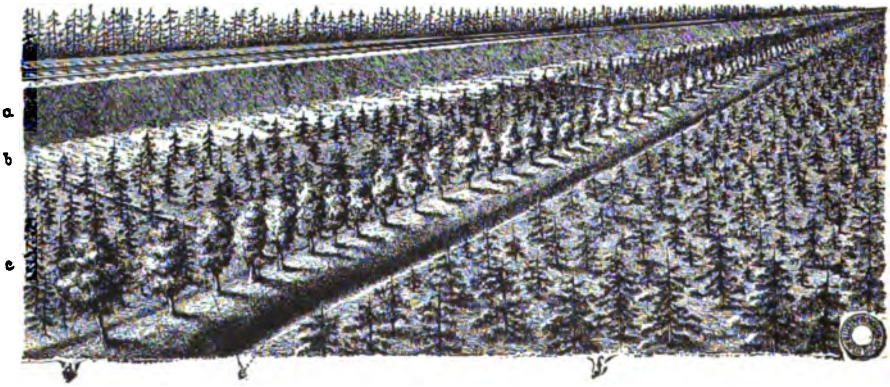

FIG. 3.—FIRE-SAFETY STRIP ALONG RAILROAD, FRENCH TURPENTINE FOREST.
[FROM U. S. DEPT. AGR. REPT.]

of the details of the method are more clearly shown in the figures 1 and 2 of Plate IV.

Figure 1 of Plate IV "exhibits the method of gathering turpentine by the Hugues system, and the use of the till and pot. While formerly the resin was allowed to run into a hole in the sand at the foot of the tree, since 1860, when the production was stimulated by the closing of the American sources of supply, an improvement on the crude method of collecting came into use. It consists in fixing a bent zinc collar or gutter cut from sheet zinc eight inches long and two inches wide, with teeth (see figure) across the chip, which acts as a lip, and conducts the liquid resin into a glazed earthen pot or a zinc vessel of conical shape suspended below the lip. The pots are six inches high, four and a half inches at the opening, and three inches at the bottom, and hold about one quart. At first placed on the ground they are fastened each season above the old chip by means of a nail through a hole or otherwise (see figure). In this way, by shortening the distance over which the resin has to flow, the evaporation of the oil is reduced and there is less liability of impurities to fall into the receiver. A cover over the pot is also sometimes used. The pots are emptied every fifteen or twenty days with the aid of a spatula. The scrape is collected only twice in the season, in June and November."*

Figure 2 of Plate IV shows a cross section of a pine tree treated according to the French method, bled at different places at different times. Some of the scars are nearly covered over with new wood (as at II), and two of the scars (as at III) have been recently made in new wood between older scars.

"Another improvement which reduces the amount of evaporation and assures cleaner resin consists in covering the chip with a board. This improvement (Hugues system) is said to yield more and purer resin, the yield is claimed to be about one-third larger, and the difference in price, on account of purity, 80 to 90 cents a barrel, while the cost per tree per year is figured at about one cent, besides the proportion of scrape is considerably reduced. This (called gallipot) is collected by hand, except the hardest impure parts (called barras), of which there is hardly any in this system of collection. Not more than 17.9 per cent. of scrape is expected, as against 29 in the American practice."*

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*An. Rep. Secretary Agr., Washington, D. C., 1892, p. 350.

Figure 3 of Plate IV "shows safety fire strip along railroad; *a* is the elevated roadbed, *b* is a strip of ground about twenty-five feet wide, which is cleared of all inflammable material. Alongside of this the wooded safety strip about fifty to sixty feet wide; *c* is a ditch five to six feet wide, a foot or so deep, the soil being thrown toward *d*. Cross ditches are made through the safety strip every 300 feet. The total width of the whole system of the road on either side is, therefore, eighty to ninety feet. The strip *b* may be used for agricultural purposes if fit for it; strip *c* remains wooded, but the forest floor is cleared out and freed of all inflammable material."†

Chipping is done forty to fifty times a season, and by the end of the first season the chipped surface has reached a height of twenty inches; that is, while the face is carried in one season just about as high in France as in the United States it is hacked from twelve to fifteen times more in the former country than here. This cup can be emptied easily and quickly by lifting it off the tree, and to prevent it being broken can be set aside while hacking and scraping is in progress, which latter operation is done once a year, in the fall. When work is begun on the second and subsequent years the cup and gutter are moved up and refastened so as to be just under the newly hacked surface. The face is rapidly carried up, the tree being hacked more frequently, but a much thinner chip being taken off than is required in the American practice, preserving all the time about the same width and same depth, so that at the end of five years it has reached a total height of twelve feet. From one to ten such faces are put on the pines, according to their size and age, and whether they are to be bled to death (*gemmage à mort*), in which event the timber will at once be utilized, or bled as long as the tree lives and an abundant flow of turpentine will permit (*gemmage à vie*).

These faces are worked only five years and then the tree is allowed to rest several years before new ones are put in. The new faces must be put in so that they will be four inches from any other

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*An. Rep. Secretary Agr., Washington, D. C., 1892, p. 350. †*Ibid.*

faces, in order that not enough of the inner bark and sap-wood will be removed at one time to kill the tree or seriously injure its life.

ADVANTAGES OF THE FRENCH SYSTEM.

The advantages of the French over the American system fall under two heads: (1). It tends more to protect the trees and prolong their activity. (2). It gives a larger yield, raises the grade of the resinous products and lessens the cost of producing.

RESULTS AS TO THE RELATIVE STRENGTH AND VITALITY OF THE TREES.

Under the French system no "boxes" are cut to weaken the trunk and make it liable to blow down, and in which, sooner or later, rot begins and finally destroys the timber value of the stem. It is in this American "box," too, always filled or covered with inflammable resin while the face is being worked, that fires usually get a start on the tree. There is no limit to the number of new sets of narrow French faces which can be placed, while from the weakening caused by the boxes only a limited number of sets of them can be cut. There are trees in the canton of Corneau (France) which have been worked for more than 200 years and show over fifty scars. The scars of the narrow faces, although they may be over twice as numerous, are more quickly covered over by the growth of new wood on both sides, since the cambium or generative tissue just under the bark will have twice as many surfaces from which to develop. This enables a tree to more quickly regain its lost vitality, upon which the yield of resin largely depends. The shallow depth which the faces in the French practice are cut, only one-third of an inch, does not injure the life process so much as the deeper cutting practiced in America, which injures the growth of the tree about two-thirds, as is shown by a comparison of the thickness of individual rings of growth before and after boxing.

The purpose the French management has in view is to both preserve and work the forests intended for the production of turpentine as long a time as possible without serious injury to the trees, since it is a matter of both time and expense to grow a body of pines suitable for tapping.

THE YIELD BY THE FRENCH SYSTEM LARGER IN QUANTITY AND BETTER IN QUALITY.

By using the cup for collecting the turpentine and moving it up each year, so that it will be just below the freshly hacked surface, a larger quantity of purer and lighter colored dip is gotten than would be possible under the American plan, and the material thus collected corresponds always to the virgin dip; it is very free from bark and makes an exceedingly high grade rosin. Under this arrangement there is very little scrape, the surface hacked that season being all that has scrape on it. The increased production in France by use of the cup method amounted to four pounds of spirits of turpentine and seven pounds of rosin from every 100 pounds of crude turpentine, and besides there were no chips or trash of any kind in the crude material. The spirits of turpentine manufactured is of a better grade than that made from crude turpentine collected by the old method, being distilled at a lower temperature and with less heat, and all of the rosin, except a small proportion made from the scrape, is of a high grade.

The value of a barrel of the crude turpentine collected by the cups is about one-fourth greater than that collected by the former system. By the cup method there is also a large saving in labor, both in scraping and dipping, and there is no loss of turpentine in dipping from a box to a bucket.

RESULTS OF EXPERIMENTS WITH THE FRENCH SYSTEM IN NORTH CAROLINA.

During the season of 1894 a trial on a limited scale was made to test the merits of the French system and to ascertain by its direct application to the long-leaf pine the exact increase of turpentine collected by it above that yielded by the American practice.

In order to reduce to a minimum the chance of errors it was decided to conduct the experiments at three separate stations under direction of different persons. At two of these stations the turpentine was to be gotten from second-year boxes and at the third station it was intended to begin a trial with first-year or virgin boxes and continue the work here for several consecutive years to ascertain the comparative annual yield.

Unfortunately in one set of the experiments with second-year boxes the value of the results was vitiated by reason of a considerable loss of turpentine from the receptacles' overflowing. The results in this case will not be considered. Careful and conscientious attention seems to have been given the third set by the person in charge, and the results seem to be of sufficient importance to be given in full. The superintendence of this work during the season was in charge of Mr. Singletery, of Bladenboro, N. C., and it was near this village that the experiment was conducted.

The pines selected for tapping were in a grove with a medium density (about seven), and had an average circumference, breast high, of six feet nine inches. These were by no means the largest trees in this grove, but were selected on account of their vigor and apparent healthiness. The soil was fair, being a moist sandy loam. The forest floor was poor, being covered with a heavy growth of wire-grass, broom grass and low huckleberries. This strip had not been burnt in several years, and since the locality was isolated, being located in the neck of a small swamp, there was little likelihood that a fire would interfere in any way with the carrying out of the experiment. Boxes, usually two to a tree, had been cut in these trees in the previous spring and the trees "worked" for one season (1893), so that there were faces twenty inches in height on each tree. Those faces were from thirteen to fifteen inches broad. Six of these old boxes, with nearly southerly aspects and with faces unshaded by surrounding shrubs, were chosen as suitable for our purpose. Above each of these old faces two narrower faces (each six inches broad) were begun side by side. This method of placing the narrow faces gave each pair of them nearly the same aspect, and since, so far as could be seen, they were under similar conditions and of the same breadth, the amount of resin which flowed from each should have been the same. Six pairs of these narrow contiguous faces were begun above the broad ones on as many different trees, care being always taken that both narrow faces of any one pair were of the same breadth.

The surface of one narrow face of each pair was continuous with the surface of the face below, which was hacked during 1893, and the turpentine which exuded from the freshly chipped surface of this narrow face was allowed to run down the entire surface of the old face into the box cut at the foot of the tree.

Across the base of the other narrow face, which began at the upper edge of the old face, a metal gutter was driven into the wood. This gutter turned the turpentine into a metal cup which hung on a staple beneath it. Chipping was begun on these faces April 20th. Both of these narrow faces were hacked at the same time and the same number of chips were taken from each face, so that the length of both faces was kept equal. Both the metal receptacles and the boxes were emptied six times during the running season. The turpentine taken from the boxes was such yellow dip as is commonly collected from second-year boxes. The grade of the turpentine collected in the metal cups was virgin dip, exceedingly free from bark, leaves and chips. It will be understood, from the fact that each of the narrow faces had a breadth of only six inches, that from the six faces in either set there should have exuded only about as much turpentine as is usually collected from three of the large-size faces, fourteen inches broad.

The net weight of the turpentine collected by all of these boxes was 21 pounds; the net weight of that collected by the cups was 24 pounds and a few ounces; that is, by the use of the cups there was a gain of one-seventh in the weight of the dip collected; or had the faces been as broad as they are usually made there would have been during the summer a gain of one pound to each face. The yield of 7 pounds to a box from these picked trees is about one-fifth more than the average yield, which is only between 5.5 and 6 pounds to a second-year box. However, this is immaterial. What we are after is the percentage of the increased yield collected in the metal cups above that of the boxes. This increase was about 15 per cent. in favor of the cups. The application of this to a crop of turpentine would mean considerable aggregate gain and would show more clearly how large the gain really is.

Working out the increased yield on this basis, *i. e.*, one pound to each box, there would be a gain of 10,000 pounds of dip to a crop of 10,000 boxes, or a gain of 35.8 barrels of dip above the 250 barrels which 10,000 boxes would have produced had each box yielded 7 pounds; or there would be gotten, instead of the 250 barrels of yellow dip from the boxes, 285.8 barrels of virgin dip by use of the cups. The difference in the amount of scrape yielded by the two systems was not near so large as the difference in the amount of dip. This difference, of course, was in favor of the boxes and amounted to less than two pounds from all six of the boxes. This loss of a pound or more was due to the loss of volatile oil by evaporation and loss of scrape which hardened on the old faces. This difference in favor of the boxes would amount in a crop to nearly 23.5 barrels of scrape.

The advantage in favor of the cups, however, lays not only in the increased yield in pounds of turpentine, but also in the higher grade of product obtained by the cups. The value of the entire yield of a crop of 10,000 boxes as determined above would amount, at present prices, to about one-fifth more if collected by the cup than if collected in the boxes. This difference in value would be distributed as follows:

Value of 285.8 barrels of virgin dip at $1.70 per barrel,		$ 485 00
Value of 250 barrels of yellow dip at $1.50 per barrel.....	$ 375 00	
And value of larger yield of 23.5 barrels of scrape at $1.10 per barrel..	26 00	401 00
Difference in favor of cups..		$ 84 00

There is an increase in value amounting to $84, or over 20 per cent. gain, even when the cups are substituted in the place of second-year boxes, and the rate of increase in value of products becomes larger each succeeding year.

As in the other experiment both cups and boxes were tried on first-year faces, of the same length, no difference is expected in the result in favor of either system. It was intended, when this experiment was begun, to move the cups, at the middle of the season, up to the top of the face which had at that time been chipped. This should have yielded, in the cups, a slightly larger amount of dip turpentine than was collected in the boxes, and the grade of that in the cups should have been higher, since the dip turpentine collected from first-year boxes is usually classed as yellow dip for the last dippings of the season.

It is expected that these experiments will be continued next season (1895) on a larger and even commercial scale to make a further test of their adaptability. This will include a test of the cheapest and most serviceable collecting cups, the best breadth to make the faces, and a trial of different materials for making gutters to ascertain their durability and strength. The use of materials with minimum cost and maximum utility will of course determine the commercial practicability of the system and it is these subjects which it is hoped will be thoroughly investigated during the next year.

The incomplete results from another experimental trial, in which the cups, on first-year faces, were, at the middle of the season, moved up so as to be at the top of the face which had so far been cut, show a gain in the number of pounds of dip collected even larger than that obtained in the preceding trial. As no scrape was collected in this trial, from a misunderstanding with the person in charge, the weight of the scrape cannot be included. It can be said, however, that there was a large difference in the amount of scrape on the two sets of faces, much the larger amount of scrape having settled on the faces with boxes.

There were twelve faces in each set, the arrangements being similar to those stated in the above experiment, except that these faces were broader—from 7 to 7½ inches—and instead of the faces being cut in pairs, one of each kind, they were placed two on each tree without regard to their aspect. The net weight of the turpentine collected from the twelve boxes was 50½ pounds, and the weight of that collected from the cups was 59 pounds, which gives a net yield in favor of the cups of 8½ pounds, or a gain of over 16 per cent. No difference in the grades was noticed in the turpentine, both being classed as virgin dip.

COST OF ADOPTING THE FRENCH SYSTEM.

The cost of the change from the old French method to the modern Hugues system was stated by Desnoyers (chief forest guard of the national forests of France) to be about one cent a year for each tree. To change from the American to the Hugues system it would not cost that much, for the cutting and cornering of the boxes, allowing two boxes to a tree and 1.4 cents for the cost of each box, amounts to nearly three cents for each tree the first year; and by the American practice one-fourth of the total yield of turpentine for six years is obtained during the first year. In the French orchards, on the other hand, the yield is very nearly the same for each year. The cups, which are made of glazed earthenware, have a hole near the upper rim which can be slipped over a hook or staple driven in the tree. Thick galvanized iron makes better gutters than zinc, as the former stands driving better and is much less injured by atmospheric influences. It is cut in strips four inches long and one and one-half inches wide, one of the longer sides being cut obliquely to the surface so that it can be easily driven into the sap-wood of the pine.

The above-mentioned facts concerning the tapping of the pine in France are taken from Samano's *Treatise on the Culture of the Maritime Pine;* Desnoyers' *Tapping of the Maritime Pine;* Prof. L. Boppe's *Forestry,* and *The Naval Store Industry* in the Report of the Chief of the Division of Forestry in the U. S. Department of Agriculture for 1892. This last mentioned publication has a very clear and concise account of the different methods of tapping, with the advantages and disadvantages of the different systems, and is well illustrated. It can probably be obtained free of charge by any one desiring to know more of the merits of the Hugues system and the condition of the naval store industry in other parts of the United States and in foreign countries.

CHAPTER IV.

THE LUMBER INDUSTRY IN EASTERN NORTH CAROLINA.

HISTORICAL SKETCH.

Until within the past two decades the production of lumber in eastern North Carolina, except for local use, had been small, owing to the great distance from general markets and the limited demand for the hard pines. Wilmington, as early as the middle of the last century, had considerable trade in long-leaf pine lumber with the West Indies and England, and this trade continued in a limited way until the first part of the present century, when with the use of steam in sawing the output was largely increased. Mr. James Sprunt, in his "*Information Concerning Wilmington, N. C.*," says that the first steam saw-mill established in Wilmington was erected on the western side of the Cape Fear river by a person named Mazerretti in the year 1818.

For a great many years after this Wilmington had a large and growing trade in lumber with the West Indies, but of late years the competition of Savannah, Mobile and Pensacola, which are much nearer to these islands, has prevented any farther expansion of the industry in that direction. Wilmington has always had a large trade in lumber with the Middle and New England States, where the long-leaf pine has been largely used in ship-building, etc.

In the last few years, owing to the increased demand for Southern hard pine, the number and capacity of the mills at Wilmington have been more than doubled. The logs for supplying this demand come from the counties along the Cape Fear, Black and North East rivers and their tributaries, along which lie well-timbered cypress, long-leaf pine and loblolly pine lands. The territory drained by these streams is about 5,000 square miles, over one-fourth of which area is timbered with long-leaf pine that can be floated to Wilmington.

As early as 1830 both Newbern and Washington had large trades in long-leaf pine lumber with foreign ports, mostly in the West

Indies. By 1860, however, owing to the exhaustion of the long-leaf pine in these sections, their trade had ceased, and since that time these points have become centers for the production of loblolly pine lumber.

LOBLOLLY PINE IN THE TIMBER MARKET.—As the supply of long-leaf pine became exhausted north of the Neuse river other pines were used in its place, the short-leaf pine being the next used and then the loblolly. In many sections these latter have always been the only pines available for building materials.

It is only within the past thirty years, however, that the loblolly pine has entered the general market in the form of lumber, being debarred, previous to that time, because of the fact that so large a proportion of it is sap wood. If used where exposed to the weather it decayed rapidly, and when used for interior work had to be painted, since it "blued" badly. The introduction of dry kilns, which enabled the sap to be thoroughly driven from the timber and the wood perfectly dried, has given it a wide range of uses. Now there is a steady demand for it, as it is extensively used for flooring, ceiling and other interior wood-work, and also for exterior work, for which latter use it is suitable only when thoroughly dried and painted. In the Northeastern States it is being used as a substitute for white pine and spruce, and as the better grades of these become scarcer and consequently more valuable the demand there for loblolly pine lumber increases and the uses to which it is put become more varied.

Since this is the chief timber tree over a large part of the State, it has been used for many years, in the section where it is the only pine, for building and fencing material. For these domestic uses only the largest stocks, and those with the most heart, were selected. For the manufacture of kiln-dried flooring and ceiling, however, those trees are preferred which have the least heart, since the sap wood furnishes a lumber more uniform in quality and color than the heart. Lumber made from the sap wood is also lighter than that from heart wood and the cost of transportation is less. It is marked in the New England and Middle States where it is sold under the name of "North Carolina pine," "North Carolina sap pine," or "North Carolina kiln-dried pine."

There has been a considerable increase in the value of loblolly pine stumpage since it has entered the general lumber market. Twenty years ago loblolly lands ranged in value from 50 cents to $1 per acre, according to situation in relation to transportation facilities and density of growth. Land similarly situated and timbered now sells from $1 to $5 an acre. Original growth loblolly lands will cut from 3,500 to 6,000 feet, board measure, to the acre; second growth from a third to a half less.

STATISTICS OF THE LUMBER INDUSTRY.

The statistics for this report on the saw-mill and forest industries of eastern North Carolina were collected in connection with an investigation of the timber lands of this section, which has just been completed. It is intended more to show the condition of the various branches of the lumber and allied industries, in respect to output and supply, than to give a general treatment of the different departments of the aggregated interests. In this connection there are but imperfect statistics for comparison, these being chiefly estimates prepared for lumber journals.

The area treated of embraces forty-three counties, which constitute the original "long-leaf pine belt" of North Carolina and to which, according to the U. S. Census of 1880, four-fifths of the milling interests of the State were at that time confined. In this enumeration are contained the products of all saw-mills and planing-mills, whether operated in connection with saw-mills or as distinct establishments, excepting entirely local planing-mills and door, sash and blind factories connected with these or distinct. There are in this section ten such local planing-mills and blind factories, which have an output with an estimated value of between $100,000 and $250,000 per annum. In spite of the fact that the latter half of the year 1893 was an era of business depression, and consequently there was a curtailed output, there is a marked increase shown in the value of the output of 1893 over that of both 1890 and 1880, according to the census reports for those years.

The value of rough and remanufactured lumber, including shingles, produced in this "long-leaf pine belt" of North Carolina for the year ending December 31, 1893, was about $4,559,000. For the census year 1880 it was $1,340,000, and for the census year 1890 it was, for the entire *State*, $5,767,687.

The output for 1893 came from 323 lumber-mills, including shingle-mills, with an aggregate capital of $4,690,000. The capital reported by the census, for the entire State, in 1890 was $5,319,500, invested in 688 establishments.

The capital engaged respectively in the manufacture of shingles and board cannot be separated, since the manufacture of shingles is largely engaged in by mills producing other lumber products. The number of mills engaged in the manufacture of lumber was 281, with an output in 1893 of 455,865,000 feet, board measure, valued at about $3,745,000. The number of shingle-mills was 65 (42 exclusively shingle-mills), with an output of 166,180,000 shingles, valued at about $813,280.

OUTPUT OF LUMBER AND SHINGLES.

The output of lumber and shingles and the capacity of the lumber and shingle-mills in operation in each county for the year ending December 31, 1893, was as follows:

Output of Lumber and Shingles, Eastern North Carolina, 1893.

COUNTIES.	Number of Establishments.	LUMBER.		SHINGLES.	
		Output in 1893, in feet, board measure.	Yearly capacity in 1893, in feet, board measure.	Output in in 1893.	Yearly capacity in shingles, 1893.
Bladen	5	2,800,000	5,400,000	3,500,000	5,000,000
Bertie	7	1,940,000	5,000,000	3,000,000	5,000,000
Beaufort	13	28,350,000	35,000,000	4,000,000	6,000,000
Brunswick	3	*2,000,000	3,500,000	....	....
Camden	5	4,500,000	6,000,000	1,300,000	4,000,000
Carteret	3	6,700,000	8,000,000	....	....
Chowan	6	24,400,000	30,000,000	3,000,000	4,500,000
Craven	16	46,700,000	53,500,000	12,300,000	15,800,000
Columbus	8	13,400,000	24,000,000	15,100,000	25,000,000
Cumberland	10	10,500,000	18,000,000	....	....
†Currituck	....	....	....	....	....
Dare	5	*2,000,000	4,005,000	6,000,000	10,000,000
Duplin	6	1,800,000	3,000,000	....	....
Edgecombe	9	*2,850,000	4,000,000	1,500,000	3,500,000
Gates	6	2,700,000	4,500,000	780,000	1,600,000
Green	11	2,300,000	5,000,000	1,500,000	2,200,000
Halifax	5	*8,000,000	14,000,000	....	....
Harnett	5	6,800,000	8,500,000	....	....
Hertford	4	3,800,000	‡........	2,500,000	4,500,000
Hyde	5	6,900,000	10,000,000	3,000,000	4,000,000
Johnston	7	*7,600,000	13,000,000	....	....
Jones	5	2,200,000	3,000,000	3,700,000	2,000,000
Lenoir	13	20,300,000	25,000,000	8,200,000	13,000,000
Martin	10	19,500,000	30,000,000	15,000,000	19,000,000
Montgomery	3	2,300,000	3,000,000	....	....
Moore	30	32,320,000	49,000,000	1,900,000	4,700,000
§Nash	6	3,550,000	4,800,000	....	....
New Hanover	8	36,000,000	48,000,000	1,500,000	1,500,000
Northampton	5	*5,800,000	8,000,000	....	....
Onslow	3	14,500,000	16,000,000	....	3,000,000
Pamlico	7	11,700,000	15,800,000	....	800,000
Pasquotank	13	22,500,000	30,000,000	19,500,000	23,000,000
Perquimans	6	4,900,000	7,000,000	3,000,000	3,900,000
Pitt	10	7,000,000	10,000,000	3,000,000	4,500,000
Pender	5	900,000	1,500,000	3,300,000	4,800,000
Robeson	12	14,700,000	18,300,000	4,000,000	7,000,000
Richmond	12	12,000,000	17,500,000	1,700,000	3,300,000
Sampson	9	1,670,000	3,800,000	400,000	950,000
Tyrrell	3	4,500,000	6,000,000	7,000,000	9,000,000
Washington	6	34,500,000	40,000,000	27,200,000	32,000,000
Wake	9	6,000,000	10,000,000	2,000,000	2,800,000
Wayne	6	8,600,000	10,000,000	300,000	1,800,000
Wilson	3	1,500,000	2,800,000	....	....
Totals	323	452,880,000	625,000,000	159,180,000	208,150,000

The figures show the quantity of lumber manufactured in each county rather than the amount cut in each. In some cases logs were carried to large mills from several adjoining counties, and are here credited to counties where sawn.

*Partly estimates made by lumbermen. †No reports made. ‡Mills destroyed before the end of the year. §Reports incomplete.

The output is at least one-tenth less than it would have been under normal trade conditions, since 107 mills, with an output of 230,000,000 feet, board measure, reported an average idleness of seven weeks. Many mills also that did not shut down considerably reduced their output during a part of the year. The unprecedented freeze during the month of January, 1893, caused many mills dependent upon the water-courses for their supply or operation to shut down for several weeks. The output would otherwise have been over 500,000,000 feet.

In the preceding statement the output for the respective counties does not necessarily mean that the timber was produced in them, but merely that it was manufactured in these counties. Camden, Chowan and Perquimans counties now produce but a small proportion of the timber manufactured in them; it comes from Bertie, up the Chowan river, and the counties lying on the southern side of Albemarle sound.

The proportion of timber produced by individual counties is more nearly represented by a subsequent table showing the amounts of timber and timbered lands held by logging and milling companies in each county, though there are given no actual figures of the production of timber by counties. There are only a few towns in the State which have a large annual output, the mills in general being scattered through the timbered districts.

The relative rank, capital invested, yearly capacity, output and value of output of the three producing points, for 1893, were as follows:

Capital, Output, etc., at Different Lumber Markets in Eastern North Carolina, 1893.

Towns.	Rank.	No. of establishments.	Capital.	Output for 1893, feet, board measure.	Yearly capacity.	Value of output, 1893.
Wilmington	1	8	$530,000*	36,000,000	48,000,000	$425,000†
Newbern‡	2	9	385,000	38,000,000	51,000,000	350,000
Washington	3	7	165,000	21,000.000	27,000,000	188,000

*Not full, partly based on a bulletin of the U. S. Census of 1890.

†Partly taken from the custom-house records of Wilmington.

‡Includes James City, a village on the opposite side of the Trent river.

The apparent disproportion between capital and value of output in the various statements is due to the different extent to which remanufacturing is carried at different places. Wilmington, too, largely increased during 1893 the capital engaged there in milling, but not sufficiently early in the year to increase the output in like ratio. The output of no shingle-mills or remanufacturing establishments except such as are connected with lumber-mills is included in the above. Elizabeth City and Edenton, with twelve mills, had a combined output of 38,000,000 feet, board measure, and 21,000,000 shingles. The shingles made in these places were largely from juniper or white cedar; the lumber was chiefly made from the loblolly pine. All except a small part of the output of Wilmington was from long-leaf pine, that of Newbern and Washington was largely loblolly pine, less than five per cent. being long-leaf. The Aberdeen district in Moore county, and the western part of Cumberland county produced in 1893 over 31,000,000 feet of long-leaf pine.

LUMBER PRODUCT FROM DIFFERENT SPECIES OF TREES.

The output in eastern North Carolina, 1893, of lumber and shingles was distributed according to kind of tree as follows:

Lumber Product from Different Kinds of Trees, 1893.

KIND OF TIMBER.	Lumber, thousand feet, board measure.	Shingles.
Loblolly pine*	288,090	....
Long-leaf pine	148,600	10,300,000
Cypress	6,275	111,680,000
Juniper (white cedar)	6,300	44,200,000
Ash	5,000	....
Yellow poplar†	2,400	....

---

*The savanna and short-leaf pine were sawn along with the loblolly and not distinguished from it, so there was no way of getting any accurate information about the quantity of these that was sawn. The savanna pine formed a large part of the material sawn at some mills in the extreme east, but there was no appreciable amount of short-leaf pine sawn except along the western boundary of the pine belt. Loblolly pine was reported as being sawn in thirty-three counties, and in twenty of these no long-leaf pine was sawn. Long-leaf pine was sawn in twenty-one counties and entirely sawn to the exclusion of the loblolly pine in six counties. The counties which produced the most loblolly pine were Beaufort, Bertie, Columbus, Craven, Dare, Gates, Halifax, Hertford, Jones, Lenoir, Martin, Onslow, Perquimans and Washington. Those which produced the most long-leaf pine were Cumberland, Moore, Richmond, Sampson and Robeson counties.

†Including small quantities of persimmon, sweet-gum, oak and dogwood.

Of the above amounts of lumber sawn there were 138,420,000 feet remanufactured at the mills, of which 101,420,000 feet were of loblolly pine and 37,000,000 feet were long-leaf pine. Besides this it is estimated that there were 45,000,000 feet of both kinds remanufactured at separate establishments in Moore, Richmond and Perquimans counties.

The amount of lumber used locally, including that shipped to other points in North Carolina, was 79,200,000 feet, of which 52,000,000 feet was long-leaf pine lumber. It seems that long-leaf pine lumber is much more widely used in the State than that made from the loblolly pine. This is because the long-leaf pine timber lasts so much longer than that of other pines when used in exposed situations, as is generally the case in this State. Most of the loblolly pine used in North Carolina is sawn in the counties where it is used. What is exported goes to the Northeastern States, about the same amount going by rail as by water. The long-leaf pine lumber, except that from Wilmington, goes to Virginia, Pennsylvania, and other interior States. That from Wilmington goes to coastwise ports and to the West Indies.

LUMBER SHIPMENTS FROM WILMINGTON.

The total shipments of lumber, the foreign exports and the value of the latter, from Wilmington for the years 1873, 1883 and each year of the past decade were as follows:

Quantity and Value of Lumber Shipped from Wilmington, 1873-'93.

YEAR.	*Total shipments of lumber, feet, b. m.	†Total foreign exports of lumber, feet, b. m.	†Value of foreign exports of lumber.	YEAR.	*Total shipments of lumber, feet, b. m.	†Total foreign exports of lumber, feet, b. m.	†Value of foreign exports of lumber.
1873	19,517,768	6,920,171	$.............	1888	41,067,686	13,019,000	$190,681
1883	40,281,158	9,074,077	....	1889	36,679,509	10,695,000	172,487
1884	37,076,042	15,319,000	232,537	1890	40,289,205	13,824,000	212,094
1885	35,956,829	14,912,000	238,983	1891	40,065,567	17,532,000	287,448
1886	39,512,249	9,053,000	145,968	1892	29,580,160	12,224,000	174,446
1887	....	11,190,000	174,121	1893	25,874,331	13,244,000	175,699

*From the records of the Wilmington Board of Trade. For the compilation of these figures and others obtained from these records the Survey is indebted to Col. J. L. Cantwell, Secretary of the Wilmington Board of Trade. These figures indicate the number of feet in board measure.

†From the custom-house records.

PRODUCTION AND EXPORT OF SHINGLES.

The greater part of the sawn cypress shingles, and all of the first-class white cedar (juniper) shingles manufactured in the State, have been exported. The greater part of the pine shingles have been used locally. Wilmington was the only point in the State that has shipped any shingles to foreign ports. It also had a large domestic trade. The total exports of shingles from Wilmington, the foreign exports, and the value of the foreign exports for the years 1873, 1883, and each year of the past decade are shown by the following table:

Quantity and Value of Shingles Exported from Wilmington, 1873–'93.

YEAR.	Total Exports.	Domestic Exports.	Foreign Exports.	Value of Foreign Exports.
1873	6,338,836	3,960,580	2,378,256	$...................
1883	6,635,851	4,748,951	1,886,900	....
1884	10,140,707	6,510,707	3,630,000	18,936
1885	7,191,335	3,894,335	3,297,000	18,936
1886	9,265,560	7,677,560	1,589,000	8,749
1887	5,726,453	3,499,453	2,227,000	11,750
1888	6,663,950	2,622,950	4,041,000	21,125
1889	7,316,912	3,593,912	3,723,000	17,946
1890	8,935,064	5,305,064	3,630,000	19,249
1891	5,958,520	3,732,520	2,226,000	12,930
1892	10,274,329	7,358,329	2,916,000	15,519
1893	18,167,500	6,314,500	1,853,000	9,806

Much the larger part of the shingles shipped from Wilmington are hand-drawn or rived cypress shingles. These are made entirely in the surrounding counties, especially those along the Cape Fear river. The making of drawn shingles, both from cypress and long-leaf pine, is an industry that has rapidly declined during the past decade. Estimates given by shingle dealers at Wilmington, Newbern and Washington, and smaller places along the seaboard, show a falling off in the production of one-half or more since 1880. This falling off is largely due to the fact that the supply of the best quality of cypress which could be easily reached in the swamps has been in a measure exhausted. The number of rived pine and cypress shingles estimated to have been made last year (1893) was 22,800,000, valued at about $55,000.

CAPITAL INVESTED IN THE LUMBER INDUSTRY.

The capital reported as invested in milling was $4,690,000. This was engaged as follows: In milling plants, stock and live assets, $3,471,100; in timber lands, $817,432; in railroads and rolling stock, $408,800. Seventy-four establishments reported that they owned or controlled 630,700 acres of timbered land. Of this 298,700 acres were loblolly pine lands, 219,200 acres were white cedar (juniper) swamp, 89,800 acres cypress and gum swamps, and 24,000 acres long-leaf pine lands. About 300,000 acres of this, including the cypress and white cedar land, is owned, and the rest is controlled for a limited number of years.

The registers of deeds of ten counties reported $158,934 invested in timber lands in their respective counties, by logging or milling companies of other States. This represented 114,995 acres of land. The swamp land amounted to 51,230 acres and the loblolly pine lands to 63,765 acres. In this connection was also reported 20,000,000 feet of standing loblolly pine, valued at $22,000. This was situated in Gates, Hertford and other northeastern counties. Bulletin No. 5 of the U. S. Census of 1890 reported 111,418 acres of yellow pine and cypress land, with an estimated total product of 953,770,000 feet, board measure, of merchantable timber, and a value of $346,885, to be owned in North Carolina by milling establishments located in Michigan and Wisconsin.

The $408,800 invested in railroads and rolling stock represents eighteen roads, with 194 miles of track and their necessary equipment. Besides this there are eight railroads exclusively or largely engaged in handling lumber and timber, which had 96 miles of track, and were taxed in 1893 on a valuation of $256,300.

The capital reported as invested by millmen in lumbering does not by any means represent the total amount of capital engaged directly or indirectly in milling. Forty-two establishments reported 171,800,000 feet, board measure, of their logs as having been brought to the mills by outside capital. This is 31 per cent. of all the logs brought to the mills. The number of persons engaged in handling this timber, taking them to be 45 per cent. of those engaged in logging, in the employment of the mills, was 1,300.

This, with the total number reported as employed by milling companies in logging, makes 2,800 engaged in this branch of the industry. The total number of hands reported as employed in the entire industry, in handling the material from the stump to the finished product, was 8,320.

The rafting of timber to the mills is done by farm laborers during the dull seasons of the year. The price paid at the mills for this timber is from $3.75 to $5 a thousand feet, board measure, for loblolly pine, and from $3 to $6 for cypress and ash, according to the quality of the timber and situation of the mill. Long-leaf pine brings the same prices as loblolly pine.

THE PRODUCTION OF LUMBER IN NORTH CAROLINA IN 1893.

Exports of Crude Lumber.—There were operating in North Carolina in 1893 three timber companies, with a capital of $40,000, reported as engaged in logging for establishments in other States. During the year 1893 there were exported by these and other logging and milling companies logs amounting to about 110,000,000 feet, board measure, to establishments in other States. This amount exported was nearly one-fourth the entire amount manufactured in the State. It consisted mostly of loblolly pine, with some cypress, and had an estimated value in raft in this State of $500,000. It went out by way of the Chowan river, and through the Dismal swamp canals and partly by rail. This timber was manufactured chiefly at Franklin, Whaleyville, Suffolk and in the vicinity of Norfolk, Va. Besides this there was exported 9,800 cords of white cedar billets, valued at $62,000, chiefly to Philadelphia, Richmond and Norfolk. This, however, cannot begin to represent the total amount shipped, since the white cedar was shipped in small amounts from a great many different places, so that but little knowledge could be gained from these sources about the amounts shipped and their value.

Recent Growth of the Lumber Industry.—An endeavor was made to ascertain the increase of capital invested in milling and the increase in output since 1890, and also to find the amount of increase during 1893. While the number of new plants erected since 1890 was gotten, the capital invested in those that had stopped running or indefinitely suspended, and their annual output, could not be accurately ascertained. The following table represents, however, very nearly the increase since 1890 in capital, annual shingle and board capacity for mills sawing long-leaf and loblolly pine and cypress lumber:

Increase Since 1890 in Capital and Productive Capacity of Lumber Mills.

	New Establishments.	Capital Invested.	Board Capacity, in feet.	Capacity in Shingles.
Loblolly pine and Cypress.....	18	$1,011,300	85,000,000	38,000,000
Long-leaf pine	14	73,000	28,000,000	2,000,000
Totals........................	32	$1,084,300	113,000,000	40,000,000

It was also ascertained that in this same time about twenty plants, with an annual output of 25,000,000 feet, had ceased running. The above increase in loblolly pine mills lay largely in Washington, Onslow, Martin, Lenoir, Halifax, Craven, Columbus and New Hanover counties, and in long-leaf mills in Moore, Nash and Cumberland counties.

The total increase in capital for the year 1893 was $392,000, and in yearly capacity was 46,000,000 feet.

There was besides this an increase for 1893 of twenty miles of logging railroad, valued, with the rolling stock, at $80,000.

MISCELLANEOUS WOOD—WORKING INDUSTRIES.

There are several minor industries in eastern North Carolina which are largely or entirely dependent upon timber for their products and which annually consume large amounts of timber or wood.

One of the most important of these industries is that engaged in the manufacture of cooperage. The stock establishments engaged in the manufacture of cooperage in North Carolina during 1893 are situated chiefly in the eastern part of the State, and included three barrel factories making truck barrels and boxes, with an output of 53,000 barrels and 1,790,000 staves, valued at $22,000; two bucket factories using white cedar; and a great number of small cooperage concerns engaged in making casks for spirits turpentine from oak, and barrels for rosin and crude turpentine from pine. The barrels for truck were made partly from pine "slabs," with wire hoops, and partly from black-gum staves with cypress hoops and yellow poplar heads.

Besides this there was a large amount of cooperage material, staves, headings and hoops, manufactured in Washington, Dare and other north-eastern counties from cypress and white cedar. The census for the year 1890 reports that there were that year eighty-three establishments manufacturing cooperage in North Carolina, with a capital of $34,542 and an output valued at $111,925.

There are a number of special manufactories in the State, including veneer works, spoke and handle factories, etc., using nothing but wood in the manufacture of their products, or largely dependent on wood. The character and extent of these manufacturing establishments and the practicability of increase in the State will be made the subject of a special Bulletin to be published by the Survey at an early date.

PRODUCTION OF TIMBER OTHER THAN MILL TIMBER.

"TON TIMBER."—The forests of eastern North Carolina once furnished a large quantity of very valuble pine stocks of exceptionally large size and superior quality, under the name of "ton timber," which were used in naval architecture, and for other purposes requiring extra large strong timbers. These stocks came from both the loblolly and long-leaf pines, the former furnishing the longest and largest pieces. The finest trees for these uses have been removed wherever accessible, and though some of these stocks are still gotten out each year their size is not so large and their quality is not so high as formerly.

During recent years the largest of these stocks have come from up the Cape Fear river, being that growth of loblolly known as rosemary pine. They are procured here and there, only a few at a place, in separate localities, by a number of contractors, so that reliable information as to the amount of production could not be obtained. However, at least 20,000 feet, scale measure, were exported last year to coastwise and to European ports. A larger quantity of this timber was shipped from Wilmington than from any other point.

RAILROAD TIES.—One of the most constant demands for the best heart pine and young white and post oaks is for making railroad cross-ties. The eastern part of this State not only furnishes all the timber required for the construction and maintenance of its own lines of railroads, but annually exports several thousand cross-ties to other States. There are about 400,000 cross-ties required yearly to maintain the existing lines of railroad. Of these 400,000 ties about one-half are all-heart long-leaf pine, and average about 7½ feet long by 9 inches broad and 6 inches thick, each containing about 3 cubic feet of wood. The oak ties are larger, especially broader, and are being used more than formerly. There are some cypress and a few white cedar ties in use, and on some roads loblolly pine ties are used. The average price paid for hewn ties is about 22 cents each. As near as could be ascertained there were 22,000 white cedar and cypress, and 30,000 pine ties, exported during the year 1893.

TELEGRAPH POLES, ETC.—These are cut from both cypress and white cedar woods. About 7,000 poles are annually required for use in this State, and besides this about 12,000 white cedar telegraph and electric light poles, valued at about $27,000, were shipped during 1893. The requirements for such white cedar poles usually are that they shall have few knots in them, and very few are cut under 14 inches in diameter at the larger end, so that the finest stocks are required to make them. It would be advisable for more care to be taken of juniper "bays" and swamps after they have been lumbered. Their soil is generally too peaty to be used for agricultural purposes. so that the only real use to which these lands can be put is to let grow on them the young white cedar left after they are cut over. Precaution should be taken to prevent these swamps from being burnt over, during dry seasons, as the forest fires not only destroy the young growth of white cedar, but also burn the thin layer of organic matter, consisting of sphagnum, peat and buried cedar logs, clear down to the sand subsoil, and thus destroy the possibility of a future supply of this timber.

THE PRODUCTION OF OAK STAVES.—From 1840 until 1880 there were annually made in the north-eastern counties many thousand white and red oak staves. During the last fifteen years, however, this industry has declined to a very small part of what it once was. Staves were very largely shipped from Beaufort county to the West Indies, prior to 1860. "Red oak staves" made from black, scarlet, water and spanish oaks were preferred for this trade; while for the European trade, which went by way of Norfolk, New York or Baltimore, "white oak staves" were preferred. The latter were made from white oak, post oak and overcup oak. Between 1868 and 1880 the counties around Albemarle sound produced large numbers of staves, but the practical exhaustion of the best accessible oak has largely reduced their output. Nash county now produces a considerable number of oak staves, and this is the only county in the eastern section of the State that does. Further west, however, large quantities of such staves are made in the upland oak forests which extend through the middle and western parts of the State to Tennessee.

AGGREGATE VALUE OF THE FOREST PRODUCTS OF EASTERN NORTH CAROLINA.

The values of all the timber and lumber products of eastern North Carolina for 1893 may be said to have been as follows:

Value of lumber, including sawn shingles	$4,558,280
" " round timber exported	562,000
" " "tun" and hewn timber exported	12,000
" " railroad ties produced	110,000
" " telegraph and electric light poles	27,000
" " hand-made shingles	55,000
" " products of special manufactories (U. S. Census, 1890),	131,055
" " cooperage products (U. S. Census, 1890)	111,925
Total	$5,567,260

To this amount can be added the value of all resinous products, which amounted, in 1893, to $1,752,760; and we have as the approximate market value of the forest products for eastern North Carolina in 1893, $7,320,020. This does not show the real total value of the forest products of this section, since practically all the fencing material is wood, and over nine-tenths of the fences are made from rails manufactured on the farms and not included in the above amounts. Neither is there included in the above any of the fire-wood, which constitutes nearly all of the fuel used in this section, both for manufacturing and domestic purposes. The value of the fencing cut up, and the cord wood in piles, would amount to considerably over $4,500,000 a year, for the quantity of both consumed in eastern North Carolina, and this added to the value of the other products, makes an aggregate value of about $12,000,000 for the forest products of this section, for one year. This makes the forest industry one of the largest in the State. The cotton crop of the entire State had in 1890 a value about equal to this amount.

RECENT TIMBER DEVELOPMENTS, AND THE OUTLOOK.

The tendency of the lumber industry in North Carolina is towards larger establishments, turning out at the mills as highly finished a product as possible, such as flooring, ceiling, moulding, etc. The wisdom of this course is fully sustained by the fact that there were in these eastern counties, in 1880, 306 establishments, which had an output valued at $1,340,000; while in 1893 there were only 323 establishments, with an output of $4,559,000. There are now in operation nine band saws, five of which have been put in since 1890; and the change from circular to band saws is being contemplated by several other establishments, since there is a saving in them, not only of motive power, but also a great saving of timber. Most large mills which will be built in the future, at least those for sawing loblolly pine, will be furnished with band saws.

The next ten years will probably show a much greater increase in milling than the past decade, and a very much larger development of the loblolly pine and hardwood industry. There are several counties in which the loblolly pine has as yet no commercial value, and in which it is only sawn in small quantities for local use. The fact that the mills using this kind of timber, and owning timber land, reported over 2,000,000,000 feet in sight, insures them sufficient material for many years to come. Besides this, the area still unlumbered and not controlled by lumber men, must have at least twice as much standing timber on it as was reported by millmen for their lands. This does not include any regrowth which is now occupying areas already lumbered.

USES OF THE IMPORTANT WOODS IN EASTERN NORTH CAROLINA.

The *long-leaf pine* serves for more uses than any other tree of this section. Its largest uses are for heavy building material for houses, bridges, trestles and other places where great strength and length of timber are required; for tank plank, flooring, ceiling, weather-boarding, shingles, railroad cross-ties, and filing. Its special qualities as a wood are not yet sufficiently understood by consumers, and it is put to a great many uses to which an inferior and weaker timber might as well be applied. Its use as tank plank is one to which it has only lately been extensively put, but one to which it is well adapted on account of its durability. It is extensively used for fencing and posts, and in the form of split rails, throughout all the south-eastern section of this State.

The *loblolly pine* is manufactured chiefly into flooring and ceiling, and to some extent into scantling for frame work, bridge timber, etc. For the last uses the wood is not so well suited as that of the long-leaf pine, though it is extensively used when the long-leaf cannot be gotten. Railroad cross-ties are made from it in the north-eastern counties, but they decay rapidly, since they are largely or entirely of sap wood, and are in contact with a soil unusually damp during the greater part of the year.

The *short-leaf* and *savanna pines* have the same uses as the loblolly, though the wood of both trees is different from that of the loblolly. The loblolly pine is also largely used for fencing.

The *yellow poplar* is manufactured into boards for box stuff, and some of the best quality of lumber into furniture squares. The poplar of the eastern swamps, however, is of an inferior quality when compared with that from the western part of the State, and can only be put to secondary uses. It makes excellent fencing.

Ash is sawn into furniture squares, banister and newel post pieces, and some of the lower grades of wood into boards. Barrel hoops are extensively made from it. Like the poplar its quality is not as high as the ash from the western counties.

White cedar (juniper) is now recognized as one of the most valuable woods of the eastern United States, and decidedly the most valuable in the eastern part of North Carolina, where it has a large and constantly increasing number of uses. It is employed for making cooperage ware, pails, tubs, railroad tank plank and boat plank, shingles, sashes, railroad ties, telegraph and telephone poles and for fencing. All of these services to which it is put are based on the property it possesses of withstanding exposure to moisture, or alternate wetting and drying, and its small shrinkage. In this State it is also used in the manufacture of cheap furniture, and is said to be particularly suited for such, being easily worked, shrinking very little, and being light.

Cypress is largely used for shingles, and in other ways in which white cedar is used. Besides, on account of its great size, wide paneling, wainscoting and building material, sashes, blinds, exterior mouldings, and other wood-work exposed to the weather, are made from it. The poorer quality wood, where it is worm-eaten and "peggy," is sawn into fence boards.

The uses reported for the other woods were very few, and indeed very little of them is being sawn. Some *sweet-gum* is sawn into lumber for making furniture, but it warps so badly that it is difficult, even when kiln-dried at once, to get good boards for shipment. A use for which it is well adapted is to make veneer ware, butter and lard dishes, crates, small baskets, etc., and it is being largely employed in such manufactures in the eastern section. For making the veneer, the gum logs are cut to a uniform length, steamed thoroughly to soften the wood, placed in a large turning lathe the chisel of which takes off a thin sheet of wood as broad as the log is long. The chisel is moved automatically nearer to the center of the log with each revolution of the latter to make the sheet taken off of a uniform thickness. These sheets are then cut to size and pressed or bent into the shape desired, and steam-dried to prevent any warping.

The *black-gum* is being used for making staves and crates for use in trucking, for which uses manufacturers say it is well suited, not being heavy, and about the cheapest material that can be gotten.

Several thousand feet of *maple* was reported by one company among their products as being sawn for use in finishing the interior of railroad cars.

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ERRATA.

Page 22, line 14 from top; read *appressed* for *oppressed.*

Page 28, line 7 from top; read *compact* for *large.*

Page 31, line 19 from bottom; read *unlumbered* for *untimbered.*

Page 33, line 9 from top; read *exploitation* for *exploration.*

Page 38, line 18 from bottom; read (p. 32) for (p. 20).

Page 42, line 12 from top; insert *annually* after *and there is.*

Page 50, line 8 from top; read *occur* for *occurs.*

Page 118, line 16 from bottom; read *tun* for *ton.*

3 1905

NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

BULLETIN No. 6.

TIMBER TREES AND FORESTS OF NORTH CAROLINA.

BY

GIFFORD PINCHOT

AND

W. W. ASHE.

WINSTON:
M. I. & J. C. STEWART, PUBLIC PRINTERS.
1897.

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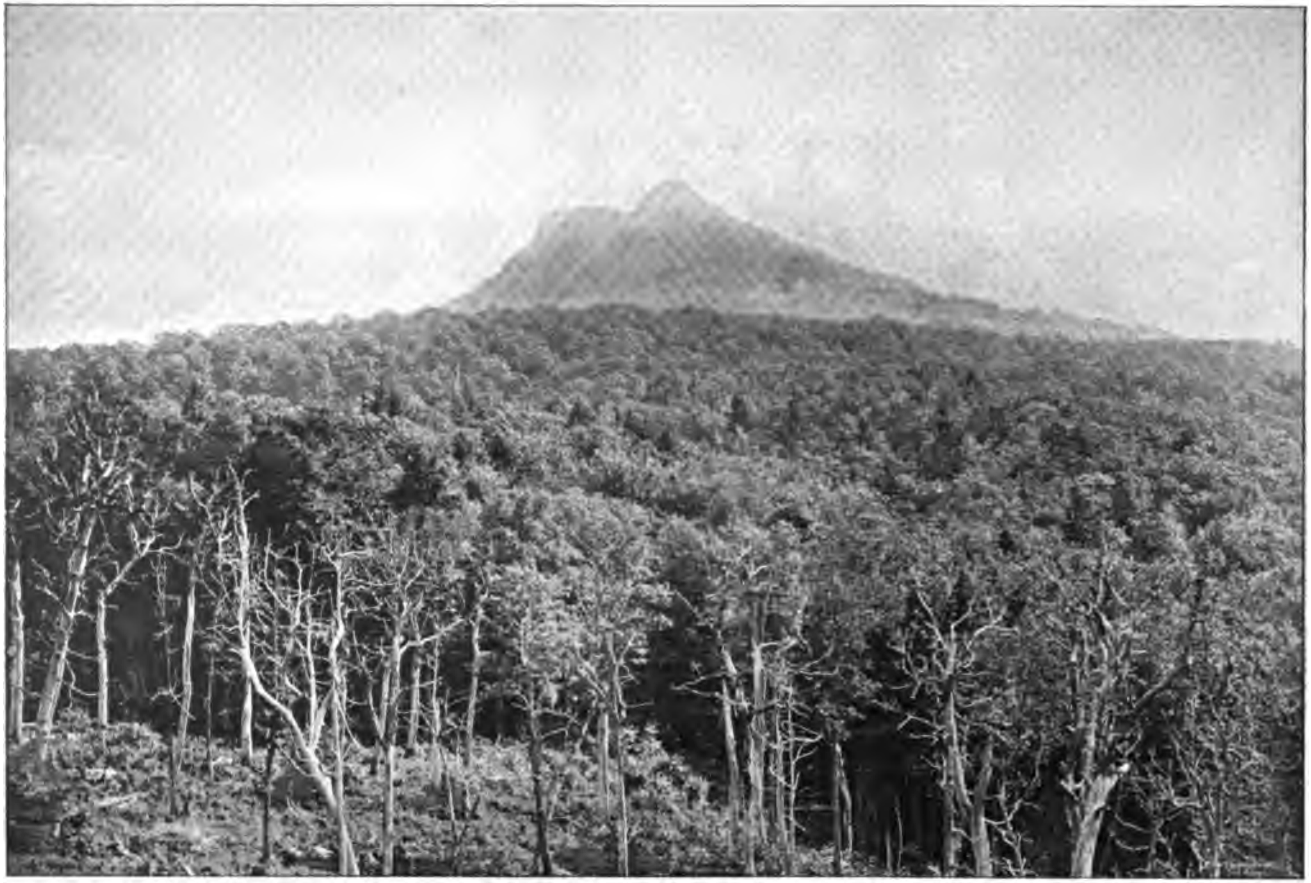

HARDWOOD FOREST ABOUT GRANDFATHER MOUNTAIN

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LETTER OF TRANSMITTAL.

CHAPEL HILL, N. C., June 19th, 1897.

To his Excellency, Gov. D. L. RUSSELL,
Chairman Geological Board, Raleigh, N. C.

SIR :—I beg to submit for publication as Bulletin 6 of the Geological Survey series, a report on the timber trees of North Carolina, by Mr. Gifford Pinchot, and a report on the forests and forest conditions in North Carolina, by Mr. W. W. Ashe. Mr. Pinchot has prepared his portion of this bulletin free of charge for services, and I regard his paper as one of the most valuable which has been prepared for the survey.

There is already a large demand for copies of this bulletin, even in advance of its being published, and its distribution will serve to answer a number of inquiries from many portions of the country, concerning the timber supplies in North Carolina.

With great respect, I beg to remain,

Yours obediently,
J. A. HOLMES,
State Geologist.

PREFACE.

The present Bulletin was planned as a part of the North Carolina forest exhibit at Chicago. It was begun before the opening of the World's Fair, but, for reasons which need not be recited here, remained unfinished. Since that time it has been continued under stress of other work as opportunity arose, and has reached it present condition only after long delays.

It is intended, first, to present a succinct statement of certain salient characteristics of the more important trees of North Carolina. The forest flora of no other State is more varied, nor in many ways so interesting as this. Partly for this reason, and partly for the uses of this Bulletin in identifying trees throughout the State, a close restriction to those species which are of present value for lumber has not been maintained.

The second part of the Bulletin, a short account of the various forest regions of the State, is contributed entirely by Mr. Ashe, whose acquaintance with the woodlands of North Carolina is so much more extensive than my own that I have thought it best not to attempt to edit his MS. in any way.

In all matters of punctuation, capitalization, and nomenclature, I have preferred to follow the established usage of the Geological Survey throughout, rather than depart from it in a few cases where my individual preference might have been different.

The material contained in the accounts of the various trees has been gathered chiefly from various publications, assisted by such personal observations as I have been able to make, or as have been contributed by different observers. I have to express my indebtedness in particular to Prof. Sargent's magnificent "Silva of North America," to Dr. Curtis' "Trees of North Carolina," and to Dr. Chapman's "Flora of the Southern States." Other authorities have been consulted in the course of preparation, but these are the principal ones.

The silvicultural notes, largely tentative in character as they must necessarily be, are intended to refer only to the bearing of each species in North Carolina.

Besides Mr. Ashe, to whose notes I am indebted for the descriptions of the root systems and for other material, and myself, many others have joined in the work, but it would carry me too far to acknowledge their services in detail. I must ask them to accept this general expression of my sincere appreciation of their assistance.

GIFFORD PINCHOT.

New York, Nov. 26, 1896.

KEY FOR THE DETERMINATION

OF THE

LARGER NORTH CAROLINA FOREST TREES.

BY

WILLIAM WILLARD ASHE.

KEY FOR THE DETERMINATION

OF THE

LARGER NORTH CAROLINA FOREST TREES.

By W. W. Ashe.

The analytical key given below for the determination of the larger forest trees is based on those characters which are most accessible and can be obtained throughout the greater part of the growing season. A short explanation of some of the terms used is given, which may be of some service.

Opposite leaves are two leaves placed opposite one another, one on either side of the twig. *Alternate leaves* are leaves not so placed in pairs along the twig.

The *leafstem* is the stalk on which the leaf stands and by which it is fastened to the twig. A *simple leaf* is one whose leafstem is attached directly to the twig; a *compound leaf*, one formed of numerous separate small leaves, or *leaflets*, which are attached at the end of a common leafstem or along either side of a common leafstem. The leaflets along the leafstem can be arranged opposite each other or alternately.

A *bud* is placed on the twig at the bottom of each leafstem. It is generally a small brown prominence or spur formed of overlapping scales. Those buds at the end of the twig are larger than those below, and the usual reference is to the end or terminal bud. Buds do not reach their full size and color until about the middle of July, but they can be clearly seen as soon as the leaves and twig are mature in spring. Most buds are placed on the twig just above where the leafstem joins it; some buds, however, are concealed in a cup hollowed out of the base of the leafstem. It is important to know where the bud is, as compound leaves are determined in this way, the small leaflets which make them having no buds where they join the leafstem, which otherwise might be taken for the twig.

The *twig* is the growth of the season. Most trees have the buds and the leaves, which grow from the same point, scattered rather regularly along the twig, only one or rarely two being at the end of the twig; the oaks, however, have from three to five such buds and leaves crowded at the end of the twig, besides those on the stem below, and this characteristic grouping of the buds is used to separate these trees from all others. Two of the magnolias have their leaves and buds so grouped, but on account of the large size of the leaves these will not be confused with the oaks.

{ The figures in parenthasis refer to the page on which a more lengthy description will be found.

I. CONIFERS, TREES WITH LIMBS, CHIEFLY EVERGREEN AND RESIN-BEARING, WITH LEAVES RARELY $\frac{1}{12}$ INCH BROAD.

(1) LEAVES OVER ONE INCH LONG, NEEDLE-LIKE, FROM 2 TO 5 COLLECTED IN A SHORT SHEATH.—*Pines.*

(*a*) Leaves 5 together; bark of small limbs whitish or gray. (p. 123.)........ WHITE PINE.

(*b*) Leaves 3 together.

Leaves 10 to 15 inches long; bud at end of the twig covered by many ragged, silvery bracts. (p. 131.)........ LONG-LEAF PINE.

Leaves 6 to 10 inches long; bud small and resinous; cone or burr cylindrical, 5 to 6 inches long. (p. 125.)........ LOBLOLLY PINE.

Leaves 4 to 8 inches long; small bud resinous; cone top-shaped; trees of eastern swamps. (p 127.)........ POND OR SAVANNA PINE.

Leaves 3 to 5 inches long; cone top-shaped; western trees on dry ridges or rarely in deep swamps; buds resinous. (p. 126.)........ (NORTHERN) PITCH PINE.

(*c*) Leaves 2 together, rarely 3.

Leaves about 4 inches long; cone less than 2 inches long; young twigs covered with a whitish or pinkish bloom; buds not resinous; large and common trees. (p. 130.)........ SHORT LEAF PINE.

Leaves about 2 inches long; cone 2½ inches long; small trees with curving branches, and thin scaly bark on old trunks. (p. 128.)........ JERSEY OR SCRUB PINE.

Leaves about 2 inches long; cone large with stout hooked prickles on the ends of the scales; a rare tree, occurring chiefly along the Blue Ridge. (p. 129.)........ TABLE-MOUNTAIN PINE.

(2) LEAVES FLATTENED, RARELY 1 INCH LONG, SCATTERED SINGLY ALONG THE TWIG; FRUIT NOT A BERRY.

(*a*) Large and common trees of eastern swamps; not evergreen; the end of the twig falling off in the autumn.

Leaves spreading in two rows, one on either side of the twig. (p. 122.)........CYPRESS.

Leaves, appressed to the twig, in many rows on all sides of it; smaller tree than the above, growing in pine barren ponds........POND CYPRESS[1].

(*b*) Trees of the mountains; evergreen.

Fruit a small burr or cone, about 1 inch long or less.

Leaves white beneath, in two rows, one on either side of the twig; growing along mountain streams. (p. 134.)........HEMLOCK.

Leaves scattered on all sides of the twig; scales of the cone larger than the last and spreading; rare trees, chiefly along the Blue Ridge. (p. 135.)........CAROLINA HEMLOCK.

Fruit a larger, cylindrical cone, 2 to 4 inches long; trees of high mountains.

Leaves green, nearly round, scattered on all sides of the twig. (p. 133.)........BLACK SPRUCE.

Leaves in one row on either side of the twig, white beneath; trees with white, smooth bark, found on the highest mountains. (p. 136.)........CAROLINA FIR OR BALSAM.

(3) LEAVES SHORT, SCALE-LIKE, LESS THAN ⅛-INCH LONG; TWIGS OF THE YEAR GREEN.—*Cedars.*

Spray, that is a bunch of twigs, flattened; fruit a small cone; trees of eastern swamps. (p. 119.)........WHITE CEDAR OR (JUNIPER.

Twigs round; fruit a small, blue berry; (often bearing large, hard, brown excrescences on twigs); dry soil. (p. 121.)........RED CEDAR.

Twigs, as well as the spray (bunch of twigs) flattened; fruit a small cone; rocky slopes of the Blue Ridge, also extensively cultivated. (p. 119.)........ARBORVITAE.

II. BROAD-LEAF TREES; TREES WITH LIMBS; LEAVES FROM ¼ OF AN INCH TO 10 INCHES BROAD, CHIEFLY DECIDUOUS.

(1) LEAVES COMPOUND AND PLACED ALTERNATELY ALONG THE TWIG.

(*a*) Leaflets placed alternately along the common leafstem, 7 to 11 in number; flowers white; fruit a dry pod; S. W. mountains; rare. (p. 56)........YELLOWWOOD.

(*b*) Stout thorns at the base of each leafstem and each leaflet; leaflets dotted with translucent dots; bark warty and thorny; sandy sea coast........PRICKLY ASH[2].

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[1] Taxodium distichum imbricaria (Nuttall) Ashe, Handbook of North Carolina, p. 43 (1896).

[2] Xanthoxylum carolinianum, Lam.

(*c*) Twigs angled, frequently bearing two flattened thorns at the base of each leafstem; leaflets not toothed, opposite on the leafstem, over 11 in number; flowers white; fruit a dry pod; bark furrowed, not thorny. (p. 54.)................YELLOW LOCUST.

(*d*) Twigs round, stout; frequently compound thorns scattered over limbs and trunk; leaves, frequently twice compound, with rather small, toothed leaflets; fruit a long, dark brown, pulpy, many-seeded pod. (p. 56.)................HONEY LOCUST.

(*e*) Twigs sticky or clammy; fruit a dry pod; Macon county, also cultivated; a shrub or in cultivation a small tree. (p. 55.)................CLAMMY LOCUST.

(*f*) Twigs smooth, bearing prominent brown buds; leaflets sharply toothed, smooth; flowers white, small, in large clusters; fruit small, red and berry-like; bruised bark on twigs bitter and scented like cherry bark; highest mountains................MOUNTAIN ASH[1].

(*g*) Twigs not thorny or sticky; usually from 2 to 4 buds above each leaf-scar; sharply toothed leaflets opposite on leafstem, over 3 inches long, 5 to 13 in number; fruit a nut, with a husk dividing in 4 parts.—*Hickories.*

Leaves and leafstems smooth, not hairy; leaflet 6 to 7: buds scaly.

Leaflets 5, smooth; no resinous particles on lower surface; nut not angled, with a thick shell and thin husk, often pear-shaped; bark not scaly. (p. 88.)................PIGNUT.

Leaflets very large, 5 or 7, smooth, but thickly dotted beneath with resinous particles; twigs, smooth, shining, purple-brown; nut angled, whitish or mealy, rather thin-shelled; the husk greenish-brown, roughened with minute prominencies, often splitting to the base; large trees with shaggy or loose bark; common. (p. 88.)................(HICKORY[2]. RED HEART OR SMALLNUT

Leaflets 5, smooth; nut white, small, sharply angled, with thin, white shell and thick husk, the fruit globular; bark very shaggy; trees of dry or rocky ridges................(HICKORY[3]. SMALL OR CAROLINA SHAGBARK

Leaflets 5 to 11, downy or hairy beneath; buds scaly.

Leaflets 5 or 7, soft-velvety beneath; nut with thick husk and thin, white shell; trees with shaggy bark. (p. 86.)....(HICKORY. SHAG OR SCALY-BARK

Leaflets 5 to 9, soft-downy beneath; twigs and buds very stout; nut brown, oblong, thick-shelled; husk thick; large trees of low grounds, with shaggy bark; infrequent................LARGE SHAGBARK HICKORY[4].

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[1] Pyrus americana, (Marshall) De Candolle.

[2] Hicoria odorata, (Marshall) Sargent.

[3] Hicoria carolinæ-septentrionalis, Ashe. Notes on the Hickories, Chapel Hill, N. C. (1896.)

[4] Hicoria laciniosa, (Michaux fils) Sargent.

Leaflets 7 to 11, rough-hairy beneath; nut thick-shelled, with thick husk; bark of tree rough but not shaggy. (p. 87.)......WHITE HICKORY.

Leaflets scurfy beneath with silvery particles; leafstem and midribs hairy; nuts thick-shelled, the husk usually adhering to it; bark very rough; small trees on sandy soil; throughout except high mountains......SAND HICKORY[1].

Leaflets 7 or more, and leafstem, often smooth; nuts thin-shelled and bitter; husk thin and adhering to the nut; end buds, long, yellow, without scales (naked).

Leaflets 7 to 11, soft-velvety or smoothish beneath: nut large, very thin-shelled and bitter; husk thin. (p. 84.)......BITTERNUT HICKORY.

Leaflets 9 to 13, smooth; nut small, very thin-shelled and bitter; confined to the lower Cape Fear section. (p. 85.) WATER (BITTERNUT) HICKORY.

(*h*) Leaflets smaller, over 11 in number; fruit a nut with a husk or rind which does not split at all on the mature nut; pith brown, chambered.—*Walnuts.*

Leaflets soft-velvety; fruit nearly round. (p. 83.) BLACK WALNUT.

Leaflets clammy or sticky; fruit oblong. (p. 84.) WHITE WALNUT.

(2) LEAVES COMPOUND AND PLACED OPPOSITE ON THE TWIG.

(*a*) Leaflets 5 or 7, spreading from the same point at the end of the leaf-stem; fruit 2 or 3 brown nuts in a yellow or brownish husk. (p. 47.)......BUCKEYE.

(*b*) Twigs and buds green and shining; leaflets 3 or 5, coarsely toothed; fruit with 2 wings. (p. 53.)......BOXELDER.

(*c*) Twigs stout and brown; buds brown and scurfy; fruit with a single wing.—*Ashes.*

(1) The very broad wing entirely surrounding the seed; leaflets 5 to 9, green both sides; eastern. (p. 78.)......WATER ASH

(2) Fruit narrowly winged at one end only; leaflets 7 to 9.

Leaves whitened beneath; twigs either smooth or velvety. (p. 70.)......WHITE ASH.

Twigs, buds and green lower surface of leaves velvety; fruit narrowly winged. (p. 72.)......RED ASH.

Twigs and leaves smooth; leaves bright green beneath, sharply toothed. (p. 73.). GREEN ASH.

(3) LEAVES SIMPLE AND PLACED OPPOSITE ON THE TWIG.

(*a*) Leaves entire, thin, oblong, large, over 2 inches long, downy beneath; flowers, slender, drooping, white; fruit plum-like......FRINGE TREE[2].

(*b*) Leaves evergreen, thick, smooth, pointed, 3 to 5 inches long; fruit large, 1-seeded; rich hummocks along the coast......DEVILWOOD OR OLIVE[3].

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[1] Hicoria villosa (Sarg.) Ashe.
[2] Chionanthus virginica, Linnæus.
[3] Osmanthus americanus, (Linnæus) Bentham & Hooker.

(*c*) Leaves toothed, oblong, small, 2 inches long; buds small and acute, or large, round, and flattened from the top; flowers seeming solitary, large and white; fruit a cluster of red berries; twigs purple or green. (p. 63.)........ DOGWOOD.

(*d*) Leaves oblong, 1½ to 3 inches long, toothed or entire-margined; buds, long-stalked, rusty-scurfy; flowers white, small, in flat-topped clusters; fruit black or bluish, containing a seed grooved on the side; small trees or shrubs........several kinds of........ BLACK HAWS [1].

(*e*) Leaves broader and short, 3 to 5-lobed; fruit with wings.—*Maples*. (The three first frequently grown as shade trees.)

Buds red, blunt; leaves white beneath, generally with 3 shallow lobes; very common; wings of fruit ¾ inch long. (p. 52.)........ RED MAPLE.

Buds red, blunt; leaves white beneath with 3 to 5 lobes; wings of fruit more than 1 inch long; cultivated. (p. 51.)........ WHITE MAPLE.

Buds brown, acute; leaves over 2 inches wide, green or white beneath with 3 lobes, each lobe 3-notched; large trees with rough, hard, shaggy bark; fruit 1¼ inch in length. (p. 50.)........ SUGAR MAPLE.

Leaves as in the sugar maple, but only half the size; fruit less than one inch long; small trees with smooth gray bark, branching near the ground; rocky river banks in the counties drained by the Yadkin and Catawba rivers........ WHITE-BARK MAPLE[2].

Small trees of the high mountains, above 3,000 feet, with striped branches, green twigs and large, smooth, 3-lobed leaves; long, stalked, purplish buds. (p. 49.).. STRIPED MAPLE.

Small trees of the highest mountains, over 4,000 feet, with purplish twigs and 3-lobed leaves, velvety beneath. (p. 48.)........ MOUNTAIN MAPLE.

(4) LEAVES SIMPLE AND ALTERNATE OR SCATTERED ALONG THE TWIG.

(*a*) Leaves mostly rather large, 3 or more inches long, nearly as broad as long, more or less heart-shaped.

(1) Small trees; leaves smooth and with entire edges; fruit a pod; flowers in early spring, bright red. (p. 57.)........ REDBUD.

(2) Larger trees, with leaves triangular, smoothish, finely toothed on the margins; buds resinous when crushed.—*Cottonwoods*.

Trees of eastern swamps; leaves

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[1] Species of Viburnum.
[2] Acer leucoderme, Small, Bul. Tor. Bot. Cl., xxii, p. 367.

finely toothed; leafstem flat; twigs angled. (p. 118.)........COTTONWOOD.

Trees of lowgrounds, eastern and middle sections; leaves finely toothed; leafstem round. (p.118.)..CAROLINA COTTONWOOD.

Trees on dry slopes of the Blue Ridge; leaves, about 2 inches long, coarsely toothed; leafstem flattened. (p. 117.)........ASPEN.

(3) Mostly trees on the mountains or cool banks; flowers white, in early summer; fruit a small, dry berry; leaves sharply toothed; twigs with large buds and inodorous bark.—*Lins or Lindens.*

Leaves thin and nearly smooth, green both sides; found chiefly around high mountains. (p. 42.)........BASSWOOD.

Leaves thickish and white beneath. (p. 45.)........LIN.

Leaves thickish, velvety beneath; found chiefly on cool hummocks near the coast. (p. 44.)........SOUTHERN LIN.

(4) Small trees of rich woodland; bark ill-scented when broken; fruit, ripening in summer, a black, edible berry; often cultivated. (p. 79.)........MULBERRY.

(*b*) Leaves about as broad as long, 2 to 5 inches long, not heart shaped in outline; buds scattered; large and common trees except last.

Leaves large, with a broad notch at the top, lobed on the sides; large buds flattened; in rich woods and along streams. (p. 39.)..TULIP-TREE OR (YELLOW POPLAR.

Leaves small, deeply 5-lobed: crushed buds resinous scented; twigs often with corky wings; fruit a rough ball, about 1 inch in diameter hanging by a stem 2 to 3 inches long. (p. 61.)........SWEET GUM.

Leaves 3 to 5-lobed, white beneath with soft wool; leafstem covering the bud; trunk of tree smooth and whitish above; fruit a rather smooth ball, about 1 inch in diameter, hanging by a slender stem; mostly along streams. (p. 81.)........SYCAMORE.

Leaves with sharp spines along their edges, thick, evergreen, dark green; trees with smooth gray bark. (p. 46.)........HOLLY.

(*c*) Leaves large, 4 to 30 inches long, oblong in outline, not toothed or lobed; flowers large and white.—*Magnolias.*

Leaves thick, evergreen, over 6 inches long, brown-hairy beneath; Brunswick county, and frequently cultivated. (p. 33.)........EVERGREEN (MAGNOLIA.

Leaves smaller, white beneath; bark white and smooth; buds silky; eastern swamps........WHITE BAY.

Leaves 4 to 6 inches long, greenish beneath; bark furrowed; buds silky-hairy; mountains........CUCUMBER TREE.

Leaves large, 10 to 30 inches long; buds silky; rare; western. (p. 36.)............GREAT-LEAVED MAGNOLIA.

Leaves 10 to 15 inches long, with a deep notch at the bottom, often collected at the end of the twig; buds not hairy; high mountains. (p. 38.)......WAHOO OR MOUNTAIN MAGNOLIA.

Leaves 10 to 20 inches long, pointed at each end, collected at the ends of the twigs; along streams. (p. 37.)..............................UMBRELLA TREE.

(*d*) Leaves longer than broad, 2 to 8 inches long; twigs mostly brown, with from 2 to 5 buds crowded at the top, other buds scattered below; fruit an acorn, i. e. a nut with the base enclosed in a scaly cup.—*Oaks.*

(1) Leaves not at all lobed or toothed, except on vigorous shoots, wedge-shaped or triangular or long and narrow in outline; leafstems short.—*Water Oaks and Willow Oaks.*

*1) Leaves green on both sides.

Leaves 4 to 6 inches long, triangular in outline, thick; buds large; twigs thick; acorn large, ¾ inch wide; small trees; bark rough, black. (p. 103.)......BLACK-JACK OAK.

Leaves narrowly triangular, 2 to 3 inches long; twigs slender; buds small and blunt; nut small; trees with smoothish gray bark; eastern. (p. 105.).........WATER OAK.

Leaves very narrow, pointed; twigs slender; in the middle and eastern parts of the State, usually in wet places. (p. 108)..WILLOW OAK.

Leaves paler beneath and downy; banks of streams along the Blue Ridge and to the westward. (p. 107).......................SHINGLE OAK.

*2) Leaves whitened beneath, 2 to 5 inches long; extreme east.

Leaves very narrow; acorn small, globose, whitened; small trees on dry sandy soil. (p. 107.).................................BARREN OR UPLAND (WILLOW OAK.

Leaves broader, evergreen; large trees, on the coast, with a long acorn. (p. 96.)...........................LIVE OAK.

(2) Leaves more or less lobed, the divisions tipped with a bristle.—*Red Oaks and Black Oaks.*

*1) Leaves with a leafstem less than 1 inch long.

Leaves broad, 3-lobed at the top. (p. 103.)......BLACK-JACK OAK.

Leaves narrow, ½ to 1 inch broad, with shallow lobes; on the sea coast. (p. 106.).................LAUREL OAK.

Leaves about 2 inches wide with 3 lobes at the top or shallow lobes on the sides; mountains..LEA'S OAK[1].

Leaves green and smooth on both sides with many long, often curved lobes; acorn large; cup with coarse, spreading scales; small trees with rough, gray bark; on pine barrens. (p. 102.)..**FORK-LEAF BLACK· (JACK OR SAND OAK.**

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[1] Quercus leana, Nuttall.

*2) Leaves with a long and slender leafstem, 1 to 3 inches long, green beneath.

Leaves over twice as long as broad, the lobes acute; rare; middle section..................**BARTRAM'S OAK**[1].

Leaves broader, generally not twice as long as broad with many lobes on each side; large trees.

§) With deep and rounded hollows between the lobes of the leaves; large trees.

Light gray bark on limbs; nut half covered by the cup; common on dry, stiff or gravelly soils; twigs brownish. (p. 99.)..........**SCARLET OAK.**

With dark gray bark on branches; only base of nut covered by the cup; rare; along streams of the middle counties; twigs steel-gray. (p. 98.)..**TEXAS RED OAK.**

§) With shallower, acute hollows between the lobes of the leaf.

Leaves downy beneath; cup covering half of the large nut; bark rough and black. (p. 101.)..........**BLACK OAK.**

Leaves smooth beneath; cup very shallow; bark striped, dark, and light gray; western. (p. 97.)..............**(NORTHERN) RED OAK.**

*3) Leaves whitened beneath; leafstem slender; nut small, globular. (p. 103.)................**SPANISH OAK.**

(3) Leaves more or less lobed or toothed, the divisions rounded and not bristle-tipped; leafstems less than 1 inch long; bark gray, furrowed or shaggy.—*White Oaks and Chestnut Oaks.*

Leaves deeply 5 to 9-lobed; nut nearly covered by the cup; in the eastern swamps. (p. 92.)..........**OVERCUP OAK.**

Leaves deeply 5 to 7-lobed; cup one-half the length of the acorn; small trees, common on dry soil. (p. 91)..................**POST OAK.**

Leaves 7 to 9-lobed; cup of acorn shallow; large trees; light gray bark; common. (p. 89.)..........**WHITE OAK.**

Leaves thick with many, rounded, shallow lobes; bark deeply furrowed; dry soil; western; acorn very large. (p. 93.)..........**ROCK CHESTNUT OAK.**

Leaves thin, velvety beneath, with many rounded, shallow lobes; bark shaggy; swamps and river banks eastward. (p. 95.)..........**SWAMP CHESTNUT OAK.**

(e) Leaves more than 3 inches long, sharply toothed on the sides and with prominent, straight veins; buds scattered along the twig, as are the leaves.

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[1] Quercus heterophylla, Michaux.

(1) Buds oblique to the axis of the twig; fruit edible, brown nuts enclosed in a prickly burr.

Leaves over 6 inches long, green both sides. (p. 109.) .... CHESTNUT.

Leaves about 4 inches long, white-downy beneath .... CHINQUAPIN[1].

(2) End bud long and slender, silky, brown; twigs unpleasant scented; leaves about 10 inches long; fruit when ripe yellow and pulpy. (p. 41.) .... PAPAW.

(*f*) Leaves about 4 inches long, veins not straight and prominent, evergreen, thick, smooth, dark green, irregularly toothed, sharply pointed; flowers large, white; fruit a woody capsule; small tree of eastern swamps with a straight trunk, not forking and narrow, conical top. (p. 42.) .... LOBLOLLY BAY.

(*g*) Leaves generally less than 3 inches long (with exceptions under §§ 1 and 2), and scattered along the twig as are the buds.

(1) LEAVES NOT TOOTHED ON THE MARGIN, 2 TO 5 INCHES LONG.

Leaves and twigs aromatic; fruit a deep blue berry on a red stalk.

Leaves evergreen, thick, dark green, hairy beneath, as is the brownish twig; eastern swamps. (p. 94.) ...... RED BAY OR SWEET BAY[2].

Leaves as in the above, but smooth beneath, as are the twigs; sandy sea coast .... SMOOTH RED BAY.

Leaves often 2 or 3-lobed; bark aromatic: fields and fence rows; twigs green .... SASSAFRAS.

Leaves and twigs not aromatic; fruit various.

Leaves thickish, smooth, evergreen, narrowed at the base; fruit many small capsules; small trees or shrubs with smooth, thin, brown bark; eastern swamps. (p. 47.) .... CYRILLA.

Leaves 2 to 4 inches long; bark not aromatic; fruit a small blue berry; common throughout the State. (p. 63.) .... BLACK GUM.

Leaves 4 to 6 inches long; rarely coarsely toothed; fruit a blue berry ¼ inch long; deep eastern swamps. (p. 65.) .... TUPELO GUM.

Leaves about 2 inches long, thick, evergreen, pointed; flowers white; fruit a black one-seeded cherry; twigs bitter; Smith's Island .... MOCK ORANGE[3].

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[1] Castanea pumila, Linnæus.

[2] Persea borbonia pubescens (Pursh) nom. nov.: P. pubescens, Sargent, Sylva, vii, p. 7 (1895).

[3] Prunus caroliniana, (Miller) Aiton.

Fruit when ripe roundish, yellow, pulpy and edible; astringent when green, the 4-lobed calyx persistent at its base; seed several, flat; fields. (p. 68.)......**PERSIMMON.**

(2) LEAVES LOBED, OR TOOTHED ON THE MARGIN.

Fruit pulpy or fleshy, as in apple or cherry.

Leaves often lobed; twigs armed with stout thorns; fruit a small sour apple one inch in diameter, yellow when ripe; flowers pink, sweet-scented. ....2 kinds of......................**CRAB APPLE**[1].

Leaves variously lobed or toothed, twigs often armed with long slender thorns; buds very small; flowers white, about ½ inch in diameter in large, flat-topped clusters, in spring; fruit, berry-like, orange or red, in clusters; small trees with bark of trunk scaly or pealing off in thin sheets or scaly....................................several kinds of........**RED (HAW) THORN**[2].

Leaves silky-hairy beneath; the edible red fruit small and berry-like; bark smooth and white. (p. 60.)..**SERVICE TREE.**

Bark of trees bitter to taste; leaves smooth, finely and sharply toothed; fruit one-seeded.

Fruit a black cherry; flowers in a drooping raceme at the end of the twig; frequent. (p. 59.)...........................**WILD BLACK CHERRY.**

Fruit a red cherry; flowers in slender, long stemmed clusters along the sides of the twig; occurs only on highest mountains. (p. 58.).......................**WILD RED CHERRY.**

Flowers in long-stemmed clusters along the sides of twig; fruit red or yellow when ripe, about ½ inch long; seed flattened; small trees, sometimes with thorny branches; fields, waste places or along streams............ ....2 kinds of.......................**WILD PLUM**[3].

Bark of tree often with corky outgrowths; fruit a small 1-seeded sweet berry; leaves thin and nearly smooth, tapering to a sharp point, unequal sided; chiefly along streams. (p. 80.)..........................**HACKBERRY.**

Fruit various, either a nut or dry.

A. Leaves over three times as long as broad.

Leaves green beneath and not hairy, finely toothed, long and narrow, ⅓ to ½ inch broad; twigs brittle, yellow or red; common along streams and wet places, except in the coastal plain where it is largely replaced by the next. (p. 116.).......................................**BLACK WILLOW.**

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[1] Pyrus coronaria, Linnæus and C. angustifolia, Alton.
[2] Species of Cratægus.
[3] Prunus americana, Marshall and P. angustifolia, Marshall.

Like the above, but the larger leaves, though smooth, whitened beneath; eastern..........WARD WILLOW[1].

Leaves whitened beneath with a fine down, at least when young; later smooth but white; twigs mostly red and purple; small slender trees, along streams, chiefly western and central..........GLAUCOUS WILLOW[2].

Twigs with no bud at the end, tipped by a hard point or white flowers or fruit; leaves 3 to 4 inches long, finely toothed, smooth, acid when chewed. (p. 66.)..........SOURWOOD.

A. Leaves less than three times as long as broad.

Terminal bud over ½ inch long; fruit a 3-angled nut, bark of trunk smooth, light gray; leaves straight-veined. (p. 111.)..........BEECH.

Small trees with smooth, light gray bark, fluted trunk, beech-like leaves and hop-like clusters of fruit; bud short; very common along streams. (p. 113.)..........HORNBEAM.

Leaves 3 to 4 inches long, sharp-pointed, downy beneath, as is the leafstem; flowers, white, bell-shaped, in drooping clusters; fruit about ½ inch long, 3-angled, the angles winged; usually small trees with striped green and brown branches; along streams and cool hollows in the mountains. (p. 70.)..........SNOWDROP-TREE.

Bark of small limbs peeling off in thin papery layers; flowers in catkins in spring; fruit cylindrical in shape, 1 inch long, covered with green bracts, each with a seed at its base within.—*Birches.*

Layers of bark red or pinkish; leaves pale beneath; common along streams. (p. 114.)....RIVER BIRCH.

Layers of bark silvery white; trees of highest mountains; leaves green beneath. (p. 113.)..........YELLOW BIRCH.

Bark of twig having the taste of wintergreen (or peppermint) when chewed; flowers and fruit of the above; trees of cool mountains. (p. 115.)..........SWEET OR CHERRY BIRCH.

The remaining native forest trees all have have small leaves. from 1 to 2 inches long long, green both sides and finely and sharply toothed. They are either *elms* or elm-like in the appearance of their foliage, and it is difficult to give accessible leaf-characters for their identification.

Twigs yellowish or light brown; buds minute, sometimes clustered; fruit a small scaly nut; bark smooth, dark gray; confined to the lower Cape Fear section..........PLANER TREE[3].

Fruit in hop-like clusters; small

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[1] Salix longipes wardii (Bebb) nom. nov.; S. nigra wardi, Bebb, Bul. U. S. Nat. Mus. No. xxii, p. 114.

[2] Salix discolor, Muehlenburg.

[3] Planera aquatica, Gmel.

trees, with shaggy, brown bark, growing on rich hillsides; western. (p. 112.)........HOP-HORNBEAM OR IRONWOOD.

Remaining large trees; fruit a winged seed falling in spring before the leaves appear; extensively cultivated for shade trees. —*Elms.*

Twigs very hairy; the leaves broadly oval, rough and hairy; twigs gummy when chewed; infrequent. (p. 78.)......................SLIPPERY ELM.

Twigs smoothish; leaves over 2 inches long, but slightly rough; bark on large trees mostly scaly. (p. 76.)..............WHITE ELM.

Twigs smoothish; the leaves about 2 inches long; bark on large trunks firm and furrowed; the bark of twigs often corky winged. (p. 77.)....................WINGED ELM.

III. PALMS; TREES WITHOUT LIMBS; lmited in this State to the PALMETTO, a small tree with unbranched stem about 10 inches in diameter and a small crown of evergreen leaves two feet or more in breadth; found only along the coast to the south of Cape Hatteras. (p. 136.)..PALMETTO.

TIMBER TREES OF NORTH CAROLINA

BY

GIFFORD PINCHOT

TIMBER TREES OF NORTH CAROLINA

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TIMBER TREES OF NORTH CAROLINA

BY GIFFORD PINCHOT

Magnolia fœtida, Sargent.*

(MAGNOLIA.)

A large pyramidal tree, with gray or light brown bark covered with small thin scales, reaching a height of 90 and a diameter of 4½ feet.

It occurs southward from the mouth of the Cape Fear river, rarely more than fifty or sixty miles from the coast, to Mosquito inlet and Tampa bay, Florida; along the Gulf coast to the valley of the Brazos river, Texas; in western Louisiana and southern Arkansas, and on the bluffs of the lower Mississippi, where it reaches its best development.

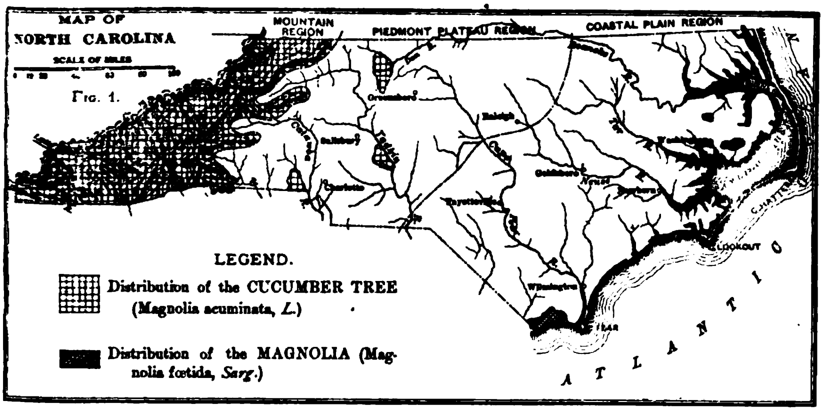


Fig. 1.

In North Carolina, where it grows to an average height of 50 to 70 feet, it is found rather sparingly in Brunswick county, in the southeast corner of the State (fig. 1), growing in the rich, moist soil of river swamps.

It reproduces itself rather slowly in the latitude of this State, and young seedlings are very rarely found in the forest, although the tree flowers and matures fruit not only regularly but, for the most part, abundantly as well.

---

*Magnolia grandiflora, Linnæus.

The long thick leathery evergreen leaves are downy underneath, and remain upon the tree for two years. The fragrant creamy-white flowers are very large and conspicuous, often 7 or 8 inches across. The oval fruit is rusty brown in color, 3 to 4 inches long by 1½ to 2½ inches broad. The winter-buds are thickly covered with dark rusty hairs. The roots, finely divided, penetrate the soil to a moderate depth.

The wood is moderately hard, close-grained, not strong, easily worked, not durable in contact with the soil, and is as valuable as that of the other magnolias; creamy-white in color; the thick sapwood nearly white. Although well suited for cabinet work and interior finish, the wood is little used except for fuel.

Magnolia glauca, Linnæus.

(WHITE BAY. SWEET BAY. SWAMP BAY.)

A slender tree, with gray branches and light brown small-scaled bark, reaching a height of 70 and a diameter of 3½ feet.

It occurs in deep, wet swamps as far north as Massachusetts, where it is reduced to a low shrub, and extends from New Jersey southward, generally near the coast, to Florida, where it reaches its best development, and southern Texas. It is not found in the

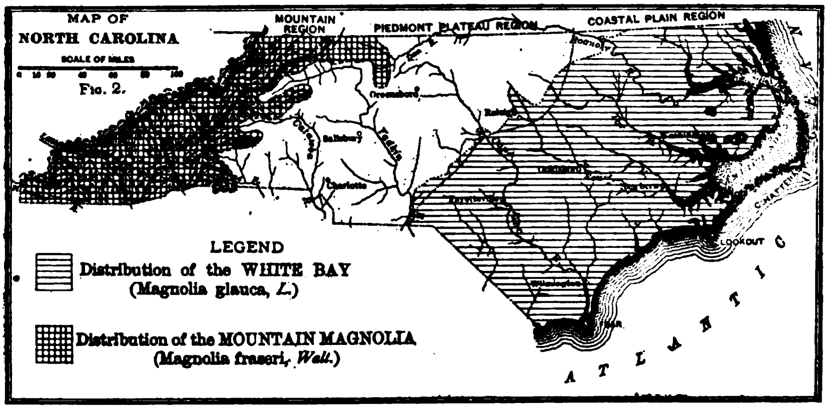


FIG. 2.

Appalachian mountains. In the South Atlantic and Gulf states it forms, with the loblolly bay and red bay, low, almost impenetrable thickets on the borders of pine barren ponds and shallow swamps, and reaches its best development in the interior of Florida.

In North Carolina, where it attains an average height of 12 to 25 feet, it is confined to wet lands or the margins of bodies of fresh or salt water in the eastern part of the Piedmont plateau and in the coastal plain region (fig. 2, p. 34), although not common in the former. In the coastal plain region there are two well-marked forms, dependent upon the quality of the soil; one, a tree of some size, the other rarely over 10 feet in height. With the white cedar it forms a large part of the growth of the "juniper bays." Sometimes after the white cedar has been cut, and usually after these swamps have been burned, thickets of this bay appear.

Seed is borne abundantly every year. The rate of growth is fairly rapid, especially in youth. Trees of all ages sprout freely from the stumps, and shoots usually appear after a tree has been killed by fire.

The oblong leaves, which are pale green above and white beneath, are partly deciduous in this State, especially toward the Piedmont plateau. The pure white fragrant flowers bloom in May, and the dark red fruit is oval, smooth, 2 inches long, and 1½ inches broad. The winter-buds are thickly covered with fine hairs. The tree has a superficial root system.

The wood is soft, light, close-grained, and not strong; light brown in color; the thick sapwood creamy-white. It is occasionally used for broom handles and woodenware. A tonic and diuretic is obtained from the bark.

Magnolia acuminata, Linnæus.

(CUCUMBER TREE.)

A tall slender tree, with furrowed dark brown bark broken into numerous thin scales, reaching a height of 90 and a diameter of 5 feet.

It occurs from western New York through southern Ontario to southern Illinois, and southward along the Appalachian mountains to southern Alabama and northeastern Mississippi. It grows sparingly in central Kentucky and Tennessee, and in portions of Arkansas, and reaches its best development in the mountains of Tennessee and the Carolinas.

In North Carolina, where it attains an average height of 60 to 80 feet and an average diameter of 3 to 4 feet, it is found on moist, fertile soil in the mountains, and rarely as far to the east of the mountains as Stanly county. (Fig. 1, p. 33.) Seed is produced frequently but seldom abundantly. Though young seedlings are common, many of them are quickly crowded out by other species when the mature trees are removed. Smaller trees sprout from the stump to a limited extent. The rate of growth is rapid.

The rather broad, pointed leaves are bright green above and slightly paler below. The yellowish-green flowers appear towards the latter part of May, and the dark red fruit is oblong, 2½ to 3 inches long by 1 inch broad. The winter-buds are densely covered with silky white hairs.

There are numerous deep lateral roots and, rarely, a taproot.

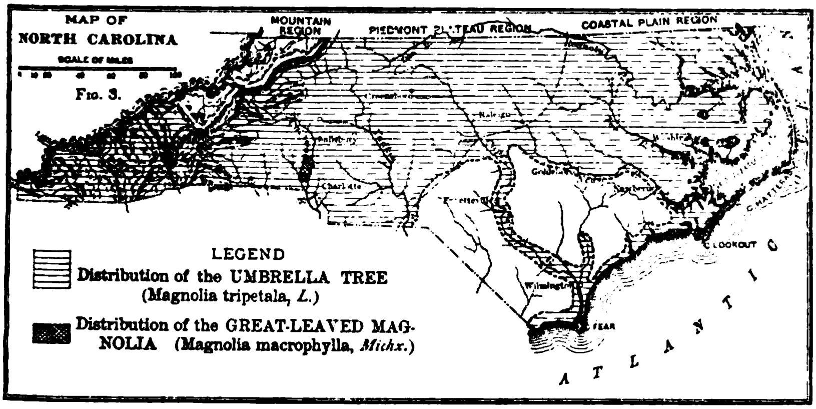
The wood is soft, satiny, light, not strong, close-grained and durable; light yellow-brown in color; the thin sapwood often nearly white. It is used for water pipes, troughs, flooring and cabinetmaking. This tree has been cut to a large extent in most of the mountain counties except Alleghany, Graham, Mitchell, Clay, Watauga, Yancey, Macon, and Swain.

Magnolia macrophylla, Michaux.

(GREAT-LEAVED MAGNOLIA.)

A spreading tree, with thin smooth, light gray bark divided into minute scales, reaching a height of 50 feet and a diameter of 20 inches.

It occurs from the sheltered valleys about the base of the Alleghany mountains of North Carolina and southeastern Kentucky, to middle and western Florida and southern Alabama, and through northern Mississippi to the valley of the Pearl river in Louisiana, and in central Arkansas, reaching its best development in northern Alabama.



In North Carolina, where it attains a height of 15 to 30 feet, it is found in Lincoln county and to some extent on the French Broad river about Asheville. (Fig. 3.)

It bears seed in large quantities at frequent intervals. Few years pass without some mast. Young seedlings are, however, uncommon in the dense woods. Young trees sprout vigorously when cut.

The leaves are very large, from 20 to 30 inches long and 9 to 10 inches broad, and are clustered at the summit of the branches. The white fragrant flowers are also large, and the bright rose-colored fruit is broadly egg-shaped and 2½ to 3 inches long. The large winter-buds are covered with thick silky white hairs. There are strong lateral and numerous fibrous roots.

The wood is hard, close-grained, light, and not strong; light brown in color; the thick sapwood light yellow. It has no commercial value.

Magnolia tripetala, Linnæus.

(UMBRELLA TREE.)

A small tree, with irregular branches, and smooth, light gray bark marked with numerous small blister-like excrescences, reaching a height of 40 feet and a diameter of 18 inches.

It occurs along the Appalachians from Pennsylvania to central Alabama, and extends in the south Atlantic states nearly to the coast, and westward to middle Kentucky, Tennessee and northwestern Mississippi, and central and southwestern Arkansas. It reaches its best development among the Smoky mountains of Tennessee and North Carolina.

In North Carolina, where it attains a height of 25 to 35 feet, it is found on rich, moist, deep soil throughout the State (fig 3, p. 37), but is nowhere common. The production of seed is frequent and abundant, and seedlings are found wherever a group of mature trees occur. It is easily propagated by shoots from the stump.

The large thin, oblong leaves are clustered at the ends of the branchlets. The conspicuous white flowers, about 5 inches in diameter, appear in May. The bright rose-colored fruit is egg-shaped, 3½ to 4 inches long. The large purple winter-buds are covered with a whitish bloom.

The wood is light, soft, weak, close-grained; brown in color; the heavier sapwood creamy-white. It has no commercial value.

Magnolia fraseri, Walter.

(MOUNTAIN MAGNOLIA. WAHOO. INDIAN BITTERS.)

A slender tree, with regular and wide-spreading or contorted branches, and dark brown, smooth or minutely scaled bark. It reaches a height of 40 feet and a diameter of 18 inches.

It occurs from the mountains of southwestern Virginia to southern Alabama and western Florida, and westward through east Tennessee and northern Mississippi to the valley of the Pearl river. It grows in the valleys of mountain streams, and reaches its best development on the tributaries of the Savannah river, and on the slopes of the Black and Big Smoky mountains. Locally abundant, it is the least widely distributed of the American magnolias.

In this State it occurs in all the counties west of the Blue Ridge and in the western parts of those immediately east of it. It is most common in Ashe, Mitchell, Yancey, Swain, Macon, Transylvania, and Burke counties. (Fig. 2, p. 34.)

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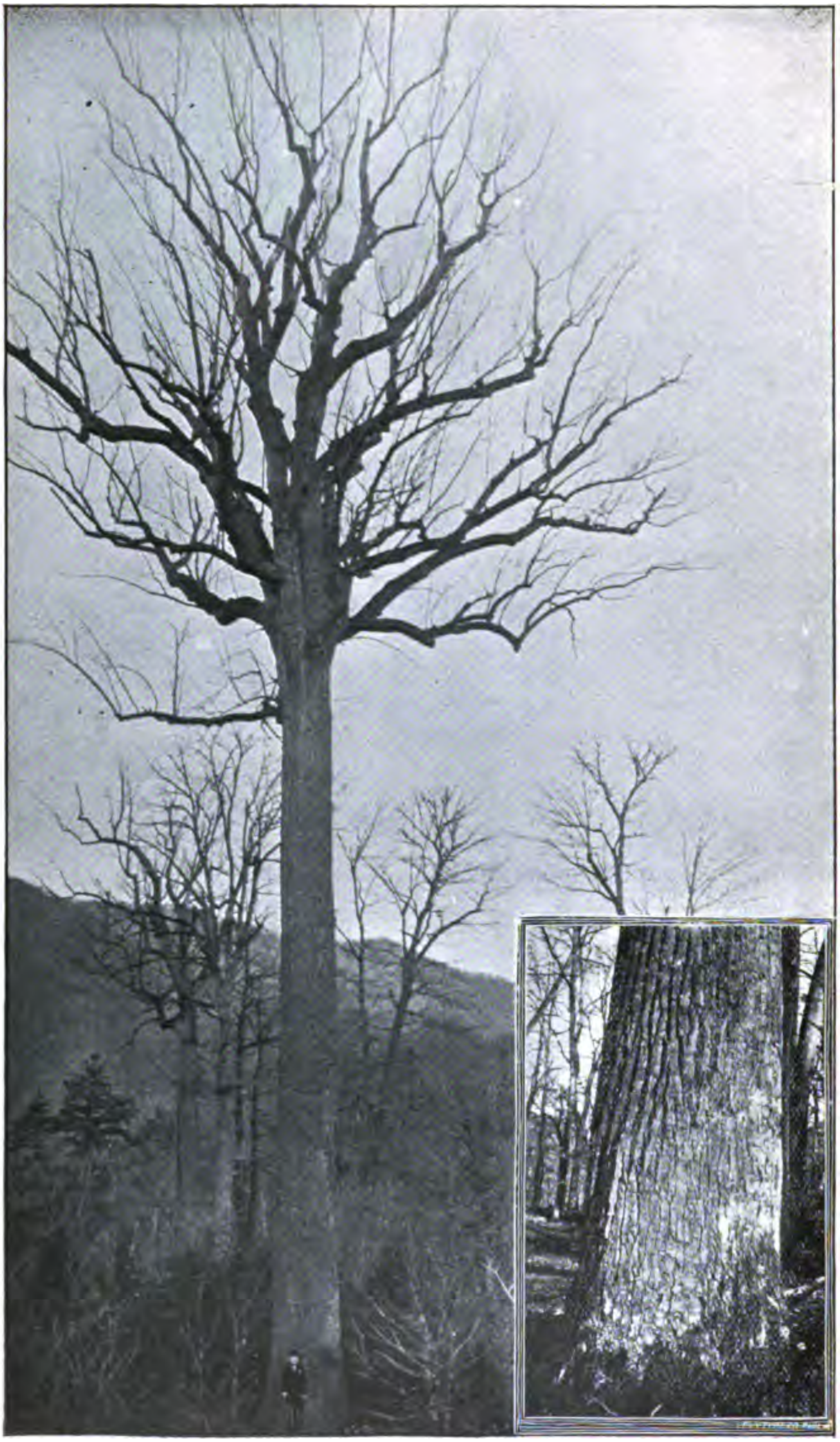

YELLOW POPLAR

Seed is produced nearly every year and young seedlings are abundant in the woods. Cattle are very fond of the young plants. Old trees are apt to be hollow at the butt and not uncommonly throughout the trunk.

The large leaves, which are crowded at the end of the branchlets, are smooth, glossy, pointed at the apex and eared at the base. When fully expanded the beautiful cream-colored flowers often measure 8 or 9 inches across. The bright rose-colored fruit is oblong, 4 to 5 inches in length and 1½ to 2 inches broad. The large winter-buds are purple.

The wood is light, soft, weak, close-grained; light brown in color; the thick sapwood creamy-white. It has no commercial value.

Liriodendron tulipifera, Linnæus.

(YELLOW POPLAR. TULIP TREE. WHITEWOOD.)

A large tree of the first commercial value, with a small pyramidal head and brownish-gray bark, reaching a height of 190 and a diameter of 10 feet. The trunk is straight and cylindrical, and in the largest specimens often free from branches to a height of from 80 to 100 feet. (Plate II.)

It occurs from Rhode Island to southwestern Vermont, west to the southern shores of Lake Michigan, and south to northern Florida, southern Alabama and Mississippi, and southeastern Missouri and the adjacent parts of Arkansas; reaching its best development on the tributaries of the Ohio and the lower slopes of the high mountains of North Carolina and Tennessee. It grows habitually in deep, rich, moist soil. Although widely distributed, it is seldom the predominant tree in the forest.

In North Carolina, where it reaches an average height of 60 to 100, and an average diameter of 3 to 4 feet, it is found in all parts of the State. (Fig. 4, p. 40.) In the coastal plain it occurs on fertile soil with sweet gum, black gum, swamp chestnut oak, and water oak, or on peaty soil with the white cedar (juniper).* Throughout this section the trees are apt to be hollow; there is a larger amount of sapwood, and the timber is inferior in quality to that in the middle and western sections. In the Piedmont pla-

*Chamæcyparis thyoides, L.

teau it is found in ravines and on north hillsides, and is largely used for cabinetmaking and interior woodwork. It is most abundant, attains its greatest size, and forms its finest timber on the lower mountain slopes in the counties west of the Blue Ridge, where trees 8 to 10 feet in diameter and more than 150 feet high are occasionally found. Throughout this region it is the chief building material.

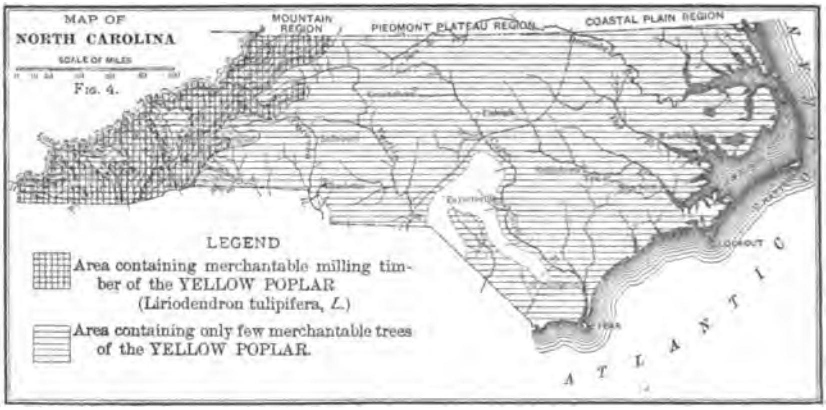

Fig. 4.

MAP OF
NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
Area containing merchantable milling timber of the YELLOW POPLAR (Liriodendron tulipifera, L.)
Area containing only few merchantable trees of the YELLOW POPLAR.
LOOKOUT
ATLANTIC

Trees growing in the open mature seed in abundance nearly every year; forest trees less frequently. Young seedlings are common in the woods and grow rapidly if not heavily shaded. Cattle eagerly devour young plants. Although trees over four feet in diameter are often hollow at the butt, it is uncommon to find the trunk unsound throughout. The quality of the timber is seldom injured by wind shakes.

The leaves are smooth, bright green, 4-lobed, with a deep rounded incision on either side and a broad shallow notch at the apex. The greenish-yellow tulip-shaped flowers appear in May, and the fruit is a narrow, light brown cone. The dark reddish winter-buds are covered with a whitish bloom.

The wood is light, soft, brittle, not strong, close and straight-grained, easily worked, and does not split or shrink easily; yellow or brown in color; the thin sapwood creamy-white. The yellow poplar is one of the most useful, as well as one of the largest, of American deciduous trees. It is largely used for construction, interior finish, boat building, shingles, pumps, and woodenware. A tonic and stimulant is made from the inner bark of the root.

Large quantities of poplar have been sawed in the last few years in eastern North Carolina and used in the manufacture of crates, trucking boxes, etc., but there is still a great deal of timber standing in the counties north of the Neuse river. The merchantable poplar has been cut for the most part in the midland counties. It has been estimated that about 500,000,000 feet of merchantable yellow poplar is standing in the mountains of western North Carolina. This is principally in Ashe, Alleghany, Watauga, Mitchell, Yancey, Haywood, Transylvania, Swain, Graham, and Macon counties. Asheville is the chief seat of the manufacture of poplar lumber; a great deal is manufactured also at Dillsboro, Magnetic City, and Cranberry. Between 12,000,000 and 13,000,000 feet of poplar was sawed for shipment during 1892 in the counties west of the Blue Ridge, and half as much more for local use.

Asimina triloba, Dunal.

(PAPAW.)

A shrub or low tree, with slender spreading branches and dark brown bark marked with large ash-colored blotches, sometimes reaching a height of 40 and a diameter of 1 foot.

It occurs from western New York and the northern shores of Lake Ontario, southward to central and eastern Pennsylvania, westward to southern Michigan, southern Indiana and eastern Kansas, and south to middle Florida and eastern Texas. It is comparatively rare toward the Atlantic seaboard, but very common in the Mississippi valley, reaching its best development along the tributaries of the lower Ohio river and the streams of central and southern Arkansas, where it grows in deep rich and rather moist soil, sometimes to the exclusion of other trees.

In North Carolina it occurs in all parts of the State, and is most abundant in the northeastern and middle sections on somewhat swampy or alluvial lands, where it reaches an average height of from 10 to 15 feet. It is rare in the sand barrens of the southeastern part, and altogether wanting in the high mountains. It reproduces itself freely.

The large deciduous leaves are sharp pointed at the apex and contracted at the base. The flowers, which are nearly 2 inches across, are a dull deep red at maturity. The edible fruit is dark brown, almost black, oblong, rounded, 3 to 5 inches long by 1 to 1½ inches broad, and from 6 to 12 ounces in weight.

The pointed winter-buds, ⅛ of an inch in length, are covered with rusty brown hairs.

The wood is light, soft, weak, coarse-grained, spongy, with the annual layers clearly marked; light yellow in color; the thin sapwood somewhat lighter.

Gordonia lasianthus, Ellis.

(BAY. BULL BAY. LOBLOLLY BAY.)

A medium size tree, with a narrow, compact head, and dark red-brown scaly bark, broken into regular shallow furrows and parallel rounded ridges. It reaches a height of 75 and a diameter of 2 feet; or is rarely a low shrub.

It occurs from the southern part of Virginia to southern Florida and westward to the valley of the Mississippi river. It is most common in Georgia and eastern Florida, reaching its best development in damp situations.

In North Carolina it occurs in the coast region, where it reaches a height of 50 to 70 feet, and a diameter of 18 to 24 inches.

It bears some seed nearly every year, and full seed years are frequent. Young seedlings are common throughout the range of the species.

The thick dark evergreen leaves are oblong, pointed at the apex and narrowly contracted at the base. The fragrant white flowers appear late in summer; and the fruit is a woody, egg-shaped capsule. The narrowly pointed winter-buds are covered with pale silky hairs.

The wood is light, soft, close-grained, not strong or durable;

light red in color; the thick sapwood lighter. It is occasionally used for cabinetmaking; and the bark has been locally employed in tanning.

Tilia americana, Linnæus.

(BASSWOOD. LIN. LINDEN.)

A tall tree, with slender, often pendulous branches, and thick, furrowed, light brown bark covered with small, thin scales. It reaches a height of 130 and a diameter of 4 feet.

It occurs in rich soil from northern New Brunswick to the southern shore of Lake Winnipeg, and southward through the Atlantic states to Virginia, along the Appalachian mountains to Alabama and Georgia, and to eastern Texas. It reaches its best development along the northern tributaries of the lower Ohio river. One of the most common trees of the northern forest, it formerly occupied exclusively large tracts of the richest land.

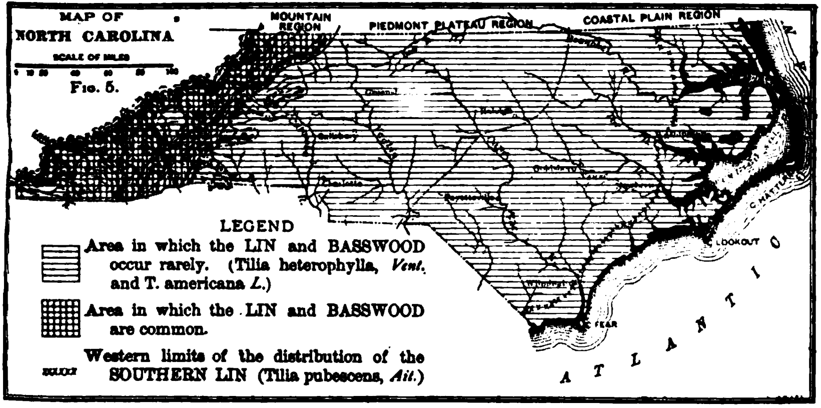
Fig. 5.
MAP OF NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
Area in which the LIN and BASSWOOD occur rarely. (Tilia heterophylla, *Vent.* and T. americana *L.*)
Area in which the LIN and BASSWOOD are common.
Western limits of the distribution of the SOUTHERN LIN (Tilia pubescens, *Ait.*)
C. HATTERAS
LOOKOUT
C. FEAR
ATLANTIC

In North Carolina, where it attains a height of 50 to 80 and a diameter of 1 to 4 feet, it is found more or less widely distributed in the mountains and in the upper part of the Piedmont plateau along the slopes of mountain spurs and higher hills, while in the lower Piedmont and coastal plain regions it is found sparsely distributed as a smaller tree. (Fig. 5.)

Basswood bears seed very abundantly every 2 or 3 years. The young growth is eagerly devoured by cattle. Specimens over 2 feet in diameter are usually hollow at the butt and not uncommonly through the entire stem. Stumps of trees which have been cut or blown down sprout vigorously. Windfalls are frequent.

The large thick roundish leaves are sharp-toothed, narrow-pointed at the apex, and unevenly heart-shaped at the base. The clusters of small white flowers are borne on an oblong, leaf-like bract, and the fruit is egg shaped, about ¼ inch in length and covered with short gray wool. The dark red winter-buds are stout, egg-shaped, and pointed. The root system is a network of strong lateral roots.

The wood is soft, straight-grained, not durable; light brown in color; the thick sapwood hardly distinguishable. It is largely used for lumber, and, under the name of whitewood, in the manufacture of woodenware and furniture, for carriage-making, and for the inner soles of shoes. It is extensively used for paper pulp, and occasionally the inner bark is made into coarse cordage and matting.

In this State it is not sawed into lumber to any considerable extent, but large numbers of trees are cut in the winter that cattle may feed upon the buds and twigs. It is much prized by apiarists because the clearest honey and whitest comb are made from its flowers.

Tilia pubescens, Aiton.

(SOUTHERN LIN. LINDEN.)

A slender tree, with a large oval crown, slender gray branches, and rough dark bark, reaching a height of 60 and a diameter of 2 feet.

It has been found as far north as Long Island, and it grows in cool, moist situations on the coast of North and South Carolina and Georgia, in northern Florida, Louisiana, and Texas. It is not a common tree.

In North Carolina, where it reaches a height of 50 to 60 feet, it occurs on deep, sandy, fertile soil, usually on the margins of swamps or streams, in the coastal plain region. (Fig. 5, p. 43.) In the Piedmont plateau region it occurs rarely, if at all.

A large proportion of the seed, which is borne frequently and in abundance, is unproductive, and seedlings are uncommon. It sprouts very freely from the stump.

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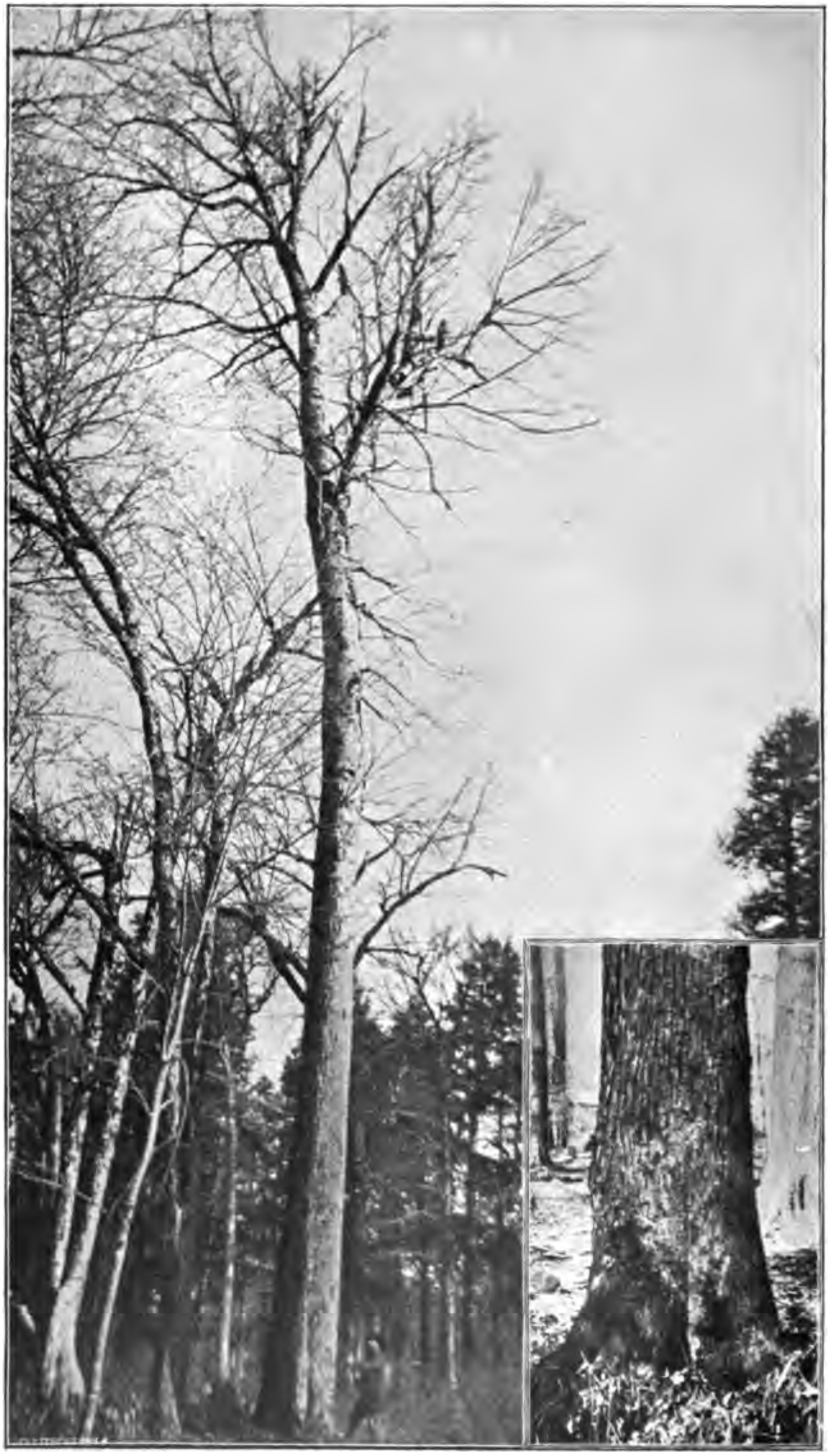

LIN OR BASSWOOD

The leaves are covered beneath with a thin, rusty down. The flowers are smaller than in the preceding species, and the dry globose fruit is small, pubescent, and usually one-seeded. The winter-buds, which are covered with a short, fine pubescence, are of a dark reddish-brown color. The Southern lin has numerous usually deeply seated lateral roots.

The wood is similar to that of Tilia americana, of which this tree has been considered a variety.

Tilia heterophylla, Ventenat.

(LIN. LINDEN.)

A tree, with slender branches forming a pyramidal head, and furrowed bark broken into short thin light brown scales, occasionally reaching a height of 60 and a diameter of 4 feet. (Plate III.)

Growing in moist soil, often over limestone rock, it occurs from Pennsylvania southward along the Appalachians to northern Alabama and central Florida, and westward to middle Tennessee, Kentucky, and southern Indiana and Illinois; and reaches its best development on the mountain slopes of eastern Tennessee. It is not common.

In this State, where it reaches an average height of 40 feet and an average diameter of 12 to 18 inches, it is most common in the mountains, (fig. 5, p. 43), and occurs sparingly in the Piedmont plateau and coastal plain. It is much more abundant in North Carolina than Tilia americana, and bears seed more frequently and generally in greater quantity. It is readily propagated by shoots. Unless protected the low growth is almost immediately eaten by cattle.

The linden borer, Saperda vestita, Say, bores into the sapwood of the standing tree.

The leaves are generally larger than those of Tilia americana, and are covered on the lower side with a silvery white down. The flowers appear earlier in the spring, and the round fruit, $\frac{3}{8}$ inch in diameter, is covered with short gray down. The egg-shaped winter-buds are bright red, covered with a whitish bloom.

The wood is soft, light, straight-grained, not durable; light brown in color; the thin sapwood hardly distinguishable. Commercially it is not distinguished from the wood of Tilia americana.

Ilex opaca, Aiton.

(HOLLY.)

A small tree, with short, slender branches, which form a pyramidal head, and roughened light gray bark, reaching a height of 50 and a diameter of 4 feet.

At the north it grows in dry gravelly soil; at the south, in rich, moist situations. It occurs from Massachusetts to Florida; in the valley of the Mississippi from southern Indiana to the gulf of Mexico; and through Missouri, Arkansas and Louisiana to eastern Texas. It is common south of the Hudson in fertile bottom lands, except in the Appalachian region and just west of it, where it is exceedingly rare; and reaches its best development in southern Arkansas and eastern Texas.

In this State, where it grows to an average height of 30 feet, and an average diameter of 12 inches, it is common except in the mountains. Specimens growing in the coast region are much larger than those found further inland.

Fertile trees generally bear seed every year, although not with uniform abundance, and young growth is common in open spots. Old trees do not sprout from the stump as readily as young ones.

The oval evergreen leaves are thick, leathery and armed with spiny teeth. The flowers are small but conspicuous from their number. The round fruit is about ¼ inch in diameter, dull red or rarely yellow in color, and remains on the tree during the winter. The winter-buds are short, blunt or pointed, the narrow-pointed scales slightly hairy on the margins. The holly has a tap-root and numerous lateral roots.

The wood is light, tough, not strong, very close-grained; nearly white in color; the thick sapwood somewhat lighter. It is easily worked, takes a beautiful polish and is much used for cabinet-making, interior finish, and turning.

The merchantable holly has been largely cut in the northeastern counties; trees large enough for commercial use still remain, however, scattered through counties on the coast.

Cyrilla racemiflora, Linnæus.

(IRONWOOD. LEATHER WOOD. BOXWOOD.)

A slender tree, with numerous wide-spreading branches, and bright red-brown scaly bark, reaching a height of 35 feet and a diameter of 14 inches; or often a broad bush.

It occurs in various situations from North Carolina southward near the coast to middle Florida, and westward to eastern Texas, reaching its best development on the coast of the gulf of Mexico.

In this State it is found usually along streams and swamps from Hertford county southward, its western limits passing through Halifax, Wake, and Anson counties.

It usually produces seed very abundantly every second year, and young trees and seedlings are common on the borders of swamps and pine barren ponds. Trees are frequently hollow through the entire stem, even when quite young, generally as the result of a broken branch.

The small thick oblong leaves are partly evergreen in the extreme eastern part of the State. The numerous whitish flowers appear in slender racemes in the early part of summer, and the very small fruit is broadly egg-shaped. The narrow-pointed winter-buds are covered with chestnut-brown scales. The roots are lateral and superficial.

The wood is heavy, hard, weak, close-grained; light brown in color; the sapwood a little lighter; and is not used in North Carolina.

Aesculus octandra, Marshall.

(BUCKEYE. SWEET BUCKEYE.)

A large straight tree, with small, rather pendulous branches and dark brown scaly bark, reaching a height of 90 and a diameter of 4 feet, or towards its southern or southwestern limit reduced to a low shrub.

It grows in deep fertile soil from Pennsylvania southward along the Alleghanies to northern Georgia and Alabama, and westward to southern Iowa and Indian Territory and western Texas, reaching its greatest development in the Alleghany mountains of Tennessee and North Carolina.

In this State it occurs as a tree in the mountains, and in the Piedmont plateau, where it is reduced to a mere shrub.

Trees growing in the open produce seed nearly every year; forest trees less frequently. Seedlings are common except in deep shade, especially in the Piedmont plateau. Young trees grow rapidly if sufficiently exposed to the light.

The buckeye stem-borers, Steganoptycha claypoleana, Fernald, and Proteoteras æsculana, Riley, penetrate the leaf-stems and twigs. Trees over 2 feet in diameter, particularly in very damp situations, are apt to be hollow or affected with dry rot.

The leaves are composed of 5 to 7 elliptical, pointed, sharply toothed leaflets. The yellowish flowers appear late in spring in large erect clusters, and the fruit is 2 or 3 inches long, with the reddish-brown seeds 1½ to 2 inches broad. The winter-buds are large and scaly.

The wood is light, soft, compact, and difficult to split; creamy-white in color; the sapwood hardly distinguishable. Although one of the commonest trees in the high mountains, it has but few uses; the softness of the wood and the fact that it decays rapidly when exposed to the weather or in contact with the soil, excludes it from construction. It is sometimes used with linden for ceiling and other interior work.

Acer spicatum, Lamarck.

(MOUNTAIN MAPLE. SWAMP DOGWOOD.)

A small bushy tree, with slender upright branches and reddish-brown bark, reaching a height of 30 feet and a diameter of 8 inches.

It occurs in the shade of other trees, from the valley of the St. Lawrence westward to northern Minnesota and the Saskatchewan region, and southward to northern Georgia; reaching its best development in the mountains of North Carolina and Tennessee.

In this State, where it is usually a shrub 6 to 10 feet high, it is confined to cold, damp places in the high mountains. It bears seed about every third year; seedlings are not common; but young sprouts are very abundant around old trees, which latter are usually hollow.

The leaves are 3 or rarely 5-lobed, coarsely toothed and downy beneath. The greenish-yellow flowers are in erect, slender clusters. The fruit is bright red in July, turning brown late in the autumn, and is rather more than an inch across. The winter-buds are sharply pointed. The root system is superficial.

The wood is light, soft, close-grained, compact; light brown in color; the sapwood being much lighter. The mountain maple does not grow large enough for commercial use.

Acer pennsylvanicum, Linnæus.

(STRIPED MAPLE. SWAMP DOGWOOD. DEERWOOD.)

A small tree, with slender, upright branches, and roughened reddish-brown bark. It reaches a height of 40 feet and a diameter of 10 inches, but is often much smaller, and shabby in habit.

It occurs from the valley of the Saguenay river westward to northeastern Minnesota, and southward to northern Georgia. It is common in the northern Atlantic states, but reaches its best development in the mountains of Tennessee and the Carolinas.

In this State it is confined to the coldest and dampest parts of the high mountains. Seed is produced annually or once in two years. Small trees are very sensitive to fire, but when burned sprout readily from the stump.

The leaves are large, 3-lobed at the end, and sharply toothed. They are much eaten by cattle. The greenish flowers occur in loose, drooping racemes, and the winged fruit is smooth, ¾ inch in length. The bright red winter-buds are stalked.

The wood is light, soft, and close-grained; light brown in color;

the thick sapwood of 30 to 40 layers of annual growth, still lighter. It is not used in North Carolina.

Acer barbatum, Michaux.*

(SUGAR MAPLE. SUGAR TREE. ROCK MAPLE.)

A large tree of great commercial value, with a broad round top when old, and light gray-brown deeply furrowed bark, reaching a height of 120 and a diameter of 4 feet. (Plate IV.)

It grows in rich woods, often forming extensive forests, and is most abundant in the mountains. It occurs from southern Newfoundland to the Lake of the Woods, southward to northern Alabama and western Florida, and westward to Minnesota, eastern Nebraska, Kansas and Texas; reaching its best development in the region of the great lakes.

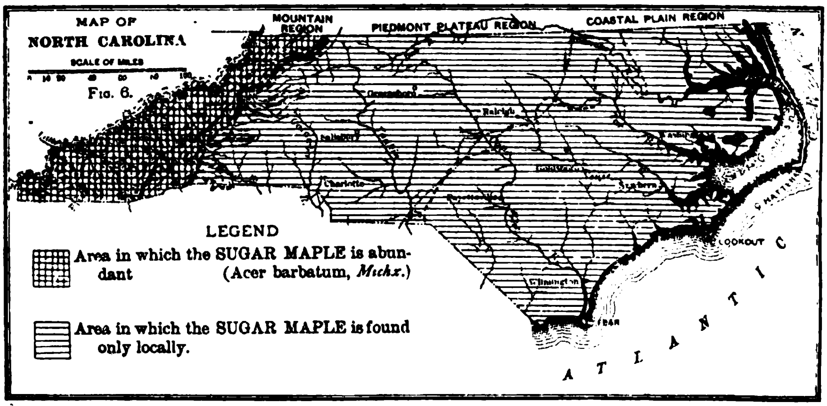
Fig. 6.

It occurs throughout this State, growing to an average height of from 50 to 80 feet and a diameter of 2 to 3 feet, but is most common in the mountains. It is a small tree in the Piedmont plateau and reduced to a mere shrub in the coastal plain region, where it is confined to borders of streams and swamps. (Fig. 6.)

The sugar maple bears seed about every third or fourth year. Seedlings are very abundant in the woods, and bear dense shade remarkably well; they spring up quickly in thinned woods, also, and where lumbering has been in progress.

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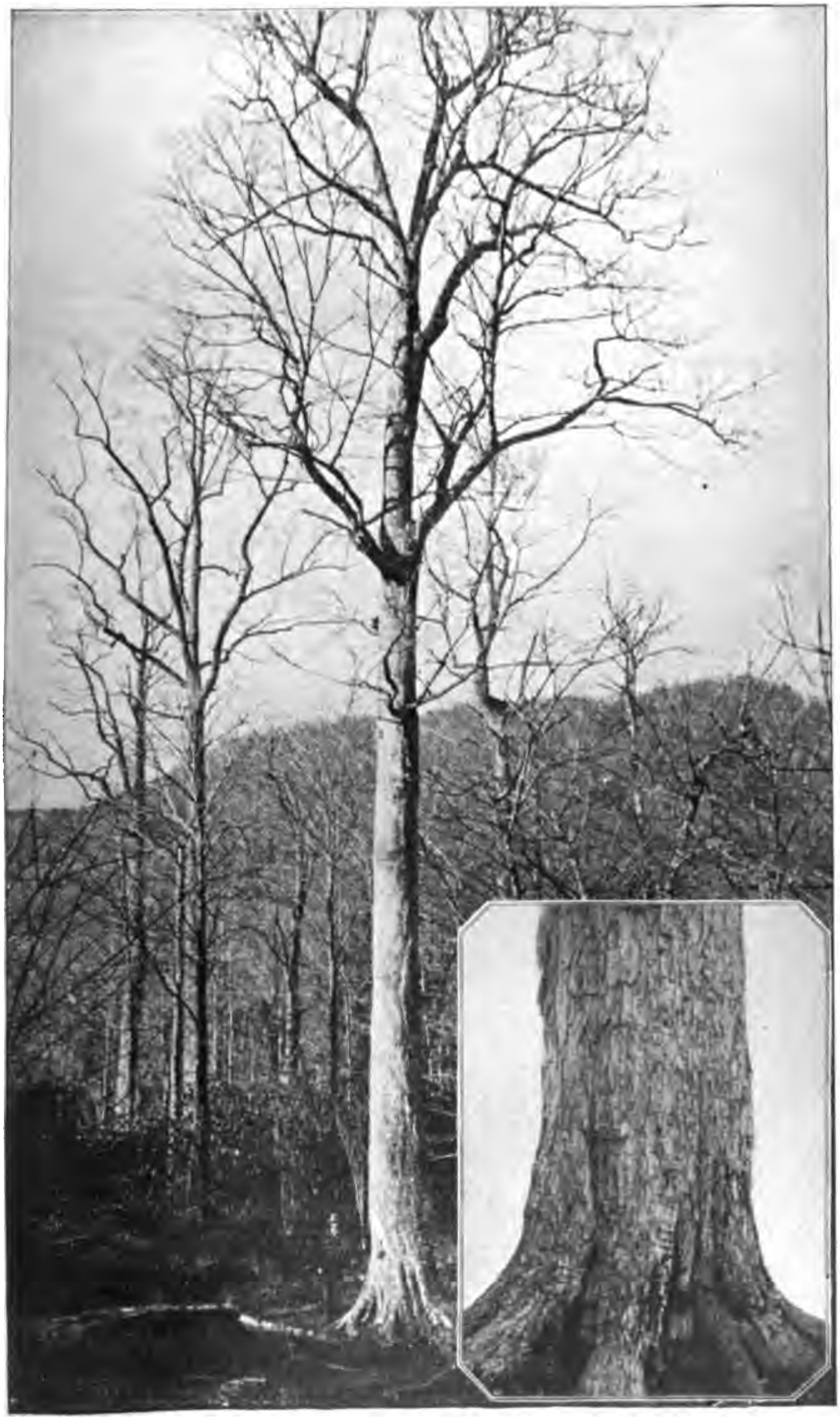
*Acer saccharinum, Wagn.



SUGAR MAPLE

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Glycobius speciosus, Say, a borer destroys the trees by girdling them or penetrating the wood, and young specimens are killed by a timber beetle, Corthylus punctatissimus, Zimm., which enters and mines the stem at or near the surface of the ground.

The leaves are 3 to 5-lobed, with rounded notches, heart-shaped at the base, smooth above, and glaucous beneath The greenish-yellow flowers occur in umbel-like clusters, appearing with the leaves in the spring. The winged fruit is an inch in length. The purple winter-buds are pointed, ¼ inch in length. The sugar maple has a tap-root and numerous strong lateral roots.

The wood is heavy, hard, strong, close-grained, tough, and takes a good polish. The heartwood is light brown; the thin sapwood, of 30 or 40 layers of annual growth, somewhat lighter. It is more valuable than the wood of any other American maple, and is largely used as fuel, for interior finish, furniture, and turnery, in ship-building, for the handles of tools, saddle-trees, shoe-lasts, shoe-pegs. Curled and bird's-eye maple are highly prized for cabinet work. Maple sugar is produced chiefly from this tree, and its ashes make a valuable fertilizer.

Acer saccharinum, Linnæus.*

(SILVER MAPLE. MAPLE. SOFT MAPLE.)

A large tree, with upright main branches and pendulous branchlets, and reddish-brown scaly bark, reaching a height of 120 and a diameter of 4 feet.

It grows in rich soil, and is most common west of the Allegheny mountains. It occurs from New Brunswick to Ontario, southward to western Florida, westward to eastern Dakota, eastern Nebraska, the valley of the Blue river, Kansas and the Indian Territory, reaching its best development in the basin of the lower Ohio river.

In this State, where it is not very common, it occurs in the upper part of the Piedmont plateau and in the mountains along streams and in cool situations, and attains a height of 30 to 50 and a diameter of 1 to 2 feet.

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*Acer dasycarpum, Ehrh.

cheap furniture, woodenware, cooperage and paper pulp. Maple sugar is occasionally made from this species.

Robinia pseudacacia, Linnæus.

(LOCUST. BLACK LOCUST. YELLOW LOCUST.)

A slender tree, with erect brittle branches forming an oblong head, and deeply furrowed dark brown bark. It reaches a height of 80 and a diameter of 4 feet.

It occurs from Pennsylvania to Georgia along the Appalachian mountains, growing with hickory, black walnut, ash, white oak, and the chestnut; and reaches its best development on the western slopes of the mountains in West Virginia. It has been naturalized in most of the states east of the Rocky mountains.

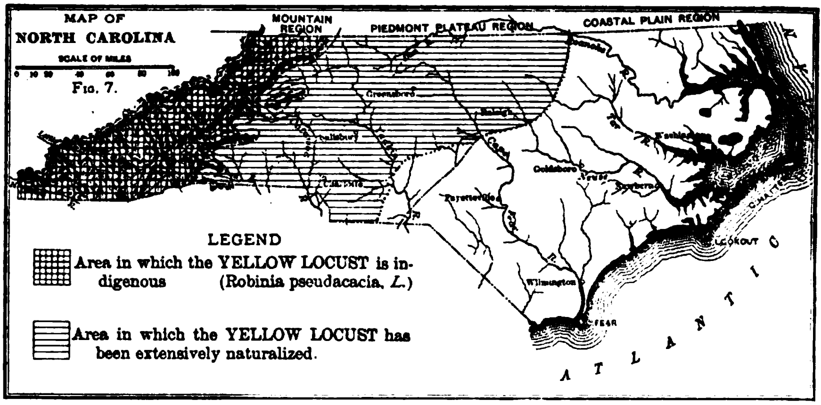

FIG. 7.

In this State it occurs on the lower ridges of the mountains, and probably for some distance east of the Blue Ridge. (Fig. 7.)

Forest trees bear seed only once in three or four years. In the open the production of seed is more frequent and seedlings, which are short-lived in the shade, more common. The locust is readily propagated by root suckers, and trees as large as one foot in diameter sprout from the stump. The growth is rapid in youth; in mature trees much slower. When cut in the forest, it is usually succeeded by oaks and chestnut. Old trees are apt to be hollow at the butt, and frequently in the upper part of the stem, from the entrance of water where the brittle limbs have been broken off.

A borer, Cyllene robiniæ, Forster, destroys the valne of large trees or kills them entirely, and bark beetles often kill the young plants. The timber is also attacked by the larvæ of Xylesthia clemensella, Chamb.

The leaves consist of from 7 to 19 thin ovate leaflets. The white flowers appear in April in large drooping clusters, and the bright red-brown fruit is a stout pod 3 to 4 inches long. The minute naked winter-buds are inconspicuous. The locust has numerous superficial lateral roots.

The wood is heavy, hard, close-grained, and very durable in contact with the soil; brown or light green in color; the very thin sapwood, of 2 to 3 layers of annual growth, pale yellow. It is extensively used in ship building and for treenails, construction, posts, and other purposes where durability in contact with the ground is desired. It is excellent fuel, and is altogether one of the most valuable timbers of the American forest. The bark of the root is tonic, purgative, and emetic.

Large quantities of locust have been cut in Jackson, Macon, Swain, and Rutherford counties.

Robinia viscosa, Ventenat.

(CLAMMY LOCUST.)

A small tree, with slender spreading branches and smooth dark brown bark, reaching a height of 40 feet and a diameter of 12 inches.

It occurs in the high mountains of the Carolinas, and has become extensively naturalized east of the Mississippi. In this State it is found on Buzzard ridge in Macon county, growing as a shrub only a few feet high. It has not been seen growing wild in any other locality since the time of Michaux.

The twigs and leaf-stalks are covered with a sticky substance. The rose-colored flowers are in short rather compact clusters and the fruit is a pod 2 to 3½ inches in length. The minute winter-buds are covered up in the scars of the leaves of the previous season.

The wood is heavy, hard, close-grained, and brown in color; the thin sapwood light yellow.

Cladrastis lutea, Koch.

(YELLOW WOOD. VIRGILIA. CHITTAM.)

A tree, with branching trunk, wide-spread pendulous branches, and smooth silvery gray or light brown bark, reaching a height of 60 and a diameter of 4 feet.

It occurs in central Kentucky, central Tennessee, on the mountains of eastern Tennessee and in North Carolina, and is one of the rarest and most local trees of eastern North America. It grows generally in rich soil, and reaches its best development near Nashville, Tenn.

In this State, where it is found in Swain, Clay, Macon, and Cherokee counties, it has an average diameter of 18 inches and a height of about 40 feet.

Large numbers of pods are borne about every second year, but they contain many abortive seeds. Seedlings are common near old trees, when cattle are excluded. Numerous sprouts come up around old trees and about live stumps.

In Clay county a large part of the foliage of yellow wood is often destroyed in the early fall by the leaf miner insect.

The leaves are composed of 7 to 11 broadly oval entire leaflets placed alternately along the leaf stalks. The white flowers are borne in long terminal drooping racemes. The fruit is a pod 1½ to 4 inches in length. The lustrous brown downy winter-buds are in fours, superposed, and crowded together to form a cone. The superficial lateral roots are long and very tough.

The wood is heavy, very hard, strong and close-grained; bright clear yellow in color; the thin sapwood almost white. It takes a good polish, is used for fuel and gunstocks, and yields a clear yellow dye.

Gleditschia triacanthos, Linnæus.

(HONEY LOCUST.)

A large tree, with slender spreading branches and dark rough deeply fissured bark, reaching a height of 140 and a diameter of 6 feet.

It occurs from Pennsylvania westward to eastern Nebraska, Kansas, and Indian Territory, southward to northern Alabama, Mississippi, and Texas, reaching its best development in southern Indiana and Illinois. It has been naturalized east of the Alleghany mountains, growing in moist fertile soil, or less commonly on dry gravelly hills.

The honey locust is scarcely known as a forest tree in North Corolina. Specimens of it, however, are found commonly on farms and along fences in the Piedmont plateau, and sparingly in the other sections.

It bears some seed every year and a large amount every third year. Seedlings, which are frequently found on dry ground under old trees, grow very rapidly. Sprouts are common about young specimens and appear quickly around the stumps of felled trees.

The leaves consist of numerous small, oblong, remotely toothed leaflets, and are sometimes doubly pinnate. The inconspicuous greenish flowers are in small spikes, and the fruit is a dark brown pod, often 10 to 18 inches in length. The minute winter-buds occur three or four together. Very sharp and rigid three-forked or simple spines, 3 to 4 inches long, and bright chestnut-brown in color, are very plentiful on some individuals and nearly or quite wanting in others. The honey locust has long superficial roots.

The wood is hard, strong, coarse-grained, and very durable in contact with the ground; red or bright red brown in color; the sapwood, of 10 to 12 layers of annual growth, thin and pale. It is largely used for fencing, for the hubs of wheels, and somewhat in construction.

Cercis canadensis, Linnæus.

(REDBUD. JUDAS TREE.)

A small tree, with a short trunk, bright red-brown furrowed bark, and smooth light brown or gray branches, reaching a height of 50 feet and a diameter of 12 inches.

It is found from New Jersey to Florida, Alabama and Mississippi, Indian Territory, Louisiana and Texas, growing on the borders of swamps and in rich bottom lands; and it reaches its best development in southern Arkansas, Indian Territory, and eastern Texas.

In North Carolina, where it attains a height of 15 to 25 feet, it occurs in the coastal plain and Piedmont plateau regions.

The dark green glossy leaves are broadly ovate, pointed at the apex, and truncate or heart-shaped. at the base. The conspicuous bright purplish-red flowers are in clusters along the branches, and appear before or with the leaves in early spring The fruit is an oblong compressed many-seeded pod, from 2½ to 3½ inches long. The winter-buds are blunt and chestnut-brown in color.

The wood is rather coarse-grained, heavy, hard, and not very strong. Its color is a rich dark brown, tinged with red; the thin sapwood lighter.

Prunus pennsylvanica, Linnæus.

(WILD RED CHERRY. FIRE CHERRY. BIRD CHERRY. PERUVIAN.)

A small tree, with slender branches, a narrow head and smooth reddish-brown, or in old trees, dark red-brown scaly bark. It reaches a height of 30 to 40 feet and a diameter of 12 to 18 inches; but at its northern and western limits it is a low shrub.

It occurs from Newfoundland to British Columbia, south through the northern states to Pennsylvania, Michigan, Illinois, and Iowa, on the eastern slopes of the Rocky mountains in Colorado, and along the Alleghany mountains of North Carolina and Tennessee; and reaches its best development on moist, rather rich soil, in the Big Smoky mountains of Tennessee. It often takes possession of ground which has been cleared by fire.

In North Carolina it is confined to damp situations on the slopes of high mountains, above an elevation of 3,500 feet. (Fig 8, p. 59)

It bears seed in great abundance, and usually every year. After spruce or Carolina balsam, or sometimes beech and maple forests, have been burned, a growth of fire cherry often springs up, but it is apt to be replaced by the original growth in about forty years, which is the average length of life for this tree.

The oblong, sharply pointed leaves are finely toothed, shining

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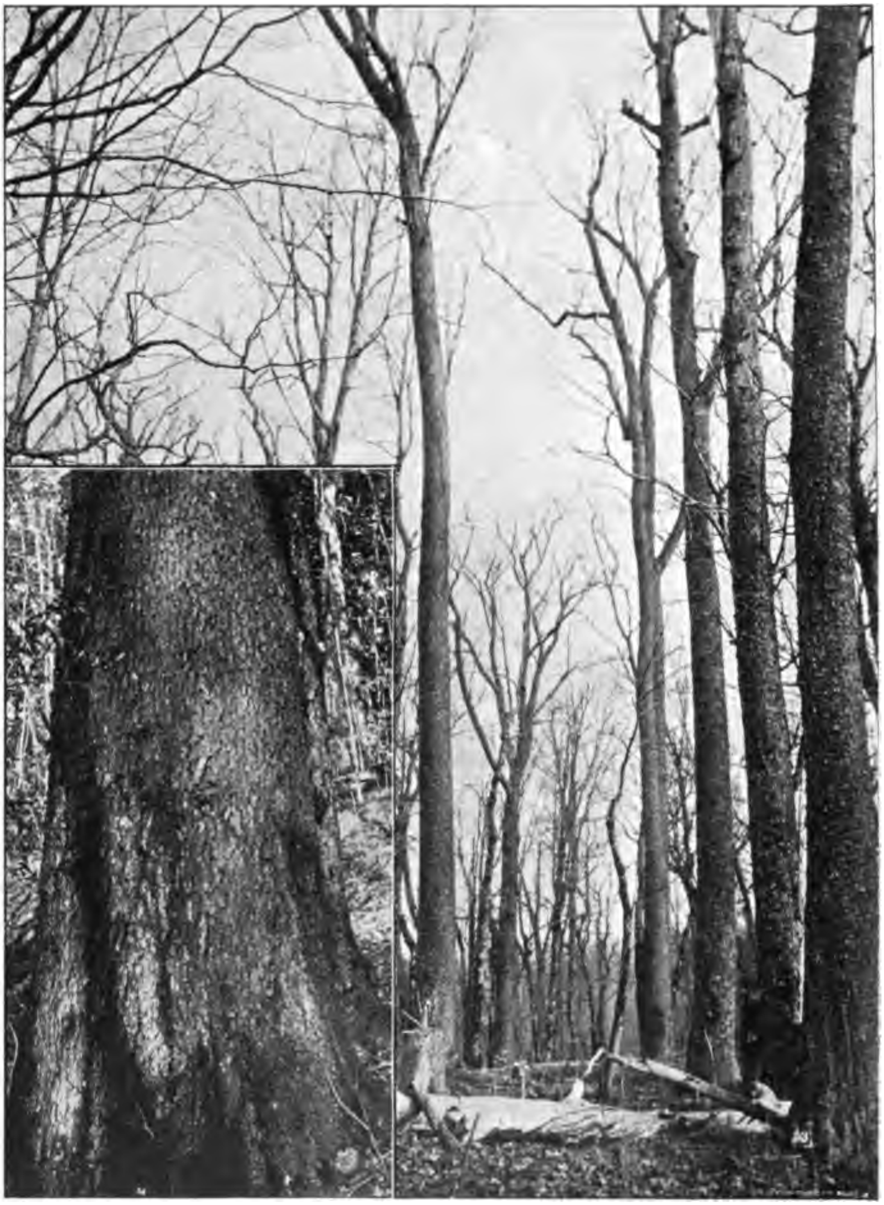

A GROUP OF WILD CHERRY TREES

green and smooth on both sides. The white flowers appear late in the spring in numerous clusters, and the fruit is small, round and bright red.

The light, soft, close-grained compact wood is light brown in color; the sapwood a clear yellow.

Prunus serotina, Ehrhardt.

(WILD BLACK CHERRY.)

A tree of the first commercial importance, with small horizontal branches and dark red-brown scaly bark, reaching a height of 100 feet and a diameter of 5 feet. (Plate V.)

It occurs from Nova Scotia to Tampa Bay in Florida, and westward to the Missouri river in Dakota, eastern Nebraska and Kansas, Indian Territory and Texas, and is found also in southern New Mexico and Arizona, and in parts of Mexico, Central and South America. It reaches its best devolopment on the high slopes of the Alleghany mountains. It was once common in all the Appalachian region, growing with the white oak, the white ash, the green ash, the sugar maple, the yellow buckeye, the hickories and the black birch.

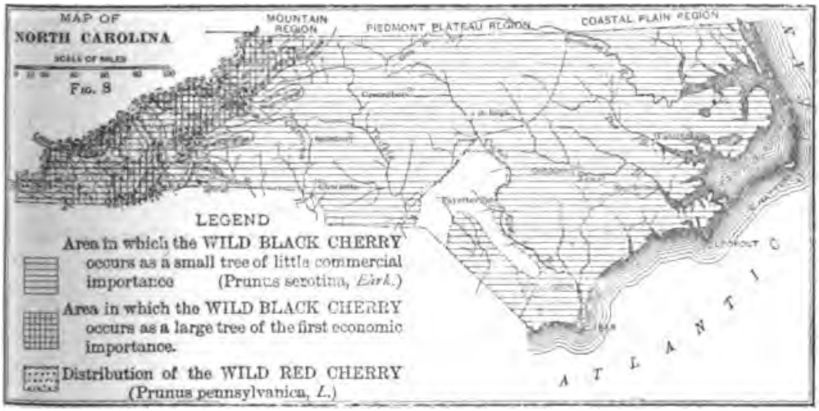
Fig. 8

MAP OF
NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
Area in which the WILD BLACK CHERRY occurs as a small tree of little commercial importance (Prunus serotina, Ehrh.)
Area in which the WILD BLACK CHERRY occurs as a large tree of the first economic importance.
Distribution of the WILD RED CHERRY (Prunus pennsylvanica, L.)
LOOKOUT C
ATLANTIC

In this State, where it attains an average height of 60 to 80 and a diameter of 2 to 3 feet, it occurs through all parts of the State, but is less common in the coastal plain, where the soil and climate are not so favorable to its growth. It reaches its best dimensions on the rich cool slopes of the mountains. (Fig. 8.)

Forest trees bear fruit abundantly about every third or fourth year; trees growing in the open more frequently. Seedlings are common in moist, rather open situations. In the higher mountains, where only it grows large enough to be of economic importance, trees over three feet in diameter are apt to be hollow or red-hearted. Old trees are often shaky. After lumbering, the black cherry is frequently followed by birch, ash, spruce, and maple.

Clisiocampa americana, Stretch, the tent caterpillar, destroys the young trees by denuding them of their foliage.

The leaves are oblong, smooth, taper-pointed, and finely-serrate with short incurved teeth. The flowers appear in late spring in long, slender, drooping racemes; and the fruit is bitter, nearly black when ripe, and from ⅓ to ½ inch in diameter. The blunt or pointed winter-buds are bright chestnut-brown.

The wood is light, strong, rather hard, with a close straight grain; light brown or red in color; the thin sapwood, of 10 or 12 layers of annual growth, yellow. It takes a beautiful polish, and no other North American wood is more suitable for cabinet-making and fine interior finish. The largest and best trees in all parts of the country have already been cut. The bark yields tonics and sedatives.

There are only a few bodies of fine trees still standing in western North Carolina. They are situated principally in Mitchell, Yancey, Swain and Macon counties.

Amelanchier canadensis, Medicus

(SERVICE TREE. SHAD BUSH. WILD CURRANT.)

A small tree, with a tall trunk, small spreading branches, and pale red-brown scaly bark, reaching a height of 50 feet and a diameter of 18 inches.

It occurs from Newfoundland along the shores of the Great Lakes, southward to northern Florida, and westward to Minnesota, eastern Nebraska, eastern Kansas, Louisiana, and southern Arkansas; reaching its best development in the mountains of North Carolina and Tennessee.

In the coastal plain region of North Carolina it is hardly more than a shrub, and is known as wild currant. It reaches its largest size on the shaded slopes of the mountains, where it is called service tree.

About every third year this tree bears fruit in large quantities; during intermediate years, sparingly or not at all. Seedlings are common in moist and shady woods.

The leaves are small, finely toothed, acute at the apex and rounded or heart-shaped at the base. The white flowers appear in drooping racemes in early spring. The sweet edible rounded fruit is dark purple when ripe, and from ⅓ to ½ inch in diameter. The pale chestnut-brown pointed winter-buds, ¼ inch long, are covered with slightly hairy scales. The service tree has numerous superficial lateral roots.

The wood is heavy, exceedingly hard, strong and close-grained; dark brown in color; the thick sapwood, of 40 to 50 layers of annual growth, lighter. It takes a good polish, and is occasionally used for the handles of tools.

In North Carolina the wood has few uses; large numbers of trees, however, are cut every year for the fruit.

Liquidambar styraciflua, Linnæus.

(SWEET GUM. RED GUM.)

A large tree, with straight cylindrical trunk, dark deeply furrowed bark, and branches often winged with corky ridges. It reaches a height of 140 and a diameter of 5 to 6 feet.

It occurs from Connecticut to Missouri, south to Central Florida and westward, through Arkansas and Indian Territory, to Texas, reaching its best development in the bottom lands of the Mississippi basin. It is common in low wet situations.

In this State, where it attains an average height of about 60 and an average diameter of 2 to 3 feet, it is common in moist situations from the coast to the mountains. (Fig. 9, p. 62.) West of the Blue Ridge it is sometimes found south of the French Broad river. It is in the coastal plain that it attains its largest dimensions, growing frequently in deep swamps with the black gum and cypress, to a diameter of 5 or 6 feet and height of one hundred feet.

Sweet gum bears fruit annually or every other year, but much of the seed is abortive. Young seedlings are common on damp hillsides and bottom lands that have been cleared, they are also frequent in damp pine woods, where, however, they seldom develop into large trees. After sweet gum has been cut a thick growth of the same species usually springs up together with yellow poplar, white oak and maple. The largest specimens are frequently hollow at the butt. This tree sprouts freely from the stump.

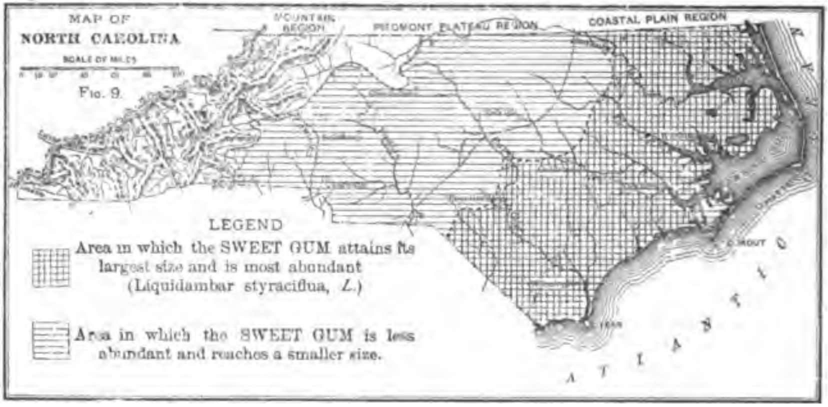

Fig. 9.

MAP OF
NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
C. LOOKOUT
C. FEAR
ATLANTIC
LEGEND
Area in which the SWEET GUM attains its largest size and is most abundant (Liquidambar styraciflua, L.)
Area in which the SWEET GUM is less abundant and reaches a smaller size.

The smooth shining leaves are deeply 5 to 7-cleft with sharp pointed finely toothed divisions. The inconspicuous flowers occur in early spring. The fruit is a long-stalked, globular, dry, rough head, hanging on the tree through the winter. The acute ovate winter-buds are dark brown in color.

The sweet gum has a very large and long tap-root, as well as long superficial roots.

The wood is heavy, hard, not strong, rather tough, close-grained, and liable to warp and shrink; bright brown in color; the sapwood nearly white. It takes a good polish and is used for flooring, clapboards, cabinet work, veneering, barrels, and street paving. The balsamic exudation is sometimes employed in cases of catarrh and as an ointment.

Only an inconsiderable quantity has been sawed in the State, but it is now being largely used for the manufacture of crates baskets, veneering, barrels, etc.

Cornus florida, Linnæus.

(DOGWOOD. FLOWERING DOGWOOD. BOXWOOD.)

A small tree, with flattened spreading top and rough blackish bark, reaching a height of 40 feet and a diameter of 18 inches.

It is common in rich woods from southern New England west to southern Ontario, and south to Florida and eastern Texas.

In this State, where it reaches an average height of 12 to 20 feet, it occurs throughout. In the coastal plain it forms a lower story under the long-leaf pine. In the Piedmont plateau and mountain region it grows under oaks, hickories and yellow poplar.

Dogwood generally bears fruit abundantly every year, and young seedlings are common in open woods, and in mixed coppice woods on moist soil. When once started it bears a deep shade. The acute ovate leaves are opposite and often somewhat clustered toward the ends of the branchlets. The flowers occur in a head surrounded by 4 white bracts, which make the cluster appear like a single large flower, and the bright red oval fruit grows in bunches. The awl-shaped leaf-buds, as well as the twigs, are purplish and covered with a whitish bloom. The rounded flattened grayish-brown flower-buds replace the terminal buds on the fertile branches. The dogwood has numerous long lateral roots.

The wood is hard, heavy, strong, close-grained, and tough; brown in color; the sapwood lighter. It takes a beautiful polish, and is extensively used for turnery, wood engraving, the bearings of machinery, the hubs of wheels, barrel hoops, shuttles, spindles, etc. The bark yields a tonic.

Large quantities have been cut in the eastern and central sections of the State, along the railroads, and manufactured into spindle, shuttle, and shoe-last blocks, but the supply has by no means been exhausted.

Nyssa sylvatica, Marshall.

(BLACK GUM. SOUR GUM.)

A large tree, with horizontal branches and short spur-like lateral branchlets, reaching a height of 100 and a diameter of 5 feet. The bark is deeply cut, light brown, often tinged with red, or, as in some large specimens in the coastal plain region of this State, scaly or nearly smooth, dark brown or black.

It occurs from Maine and Vermont to central Michigan, and southward to Tampa bay, Florida, and the Brazos river, Texas.

In North Carolina, where it has an average height of 50 to 60 feet and an average diameter of about 2 feet, it occurs in the swamps and wet lands of the coastal plain and Piedmont plateau, and in the mountains up to an elevation of 3,000 feet, along dry ridges with red and white oaks and chestnut. In the eastern sections, with the sweet gum and water ash, it forms a large part of the growth of the deeper swamps, and there reaches its largest size within the State. (Fig. 10.)

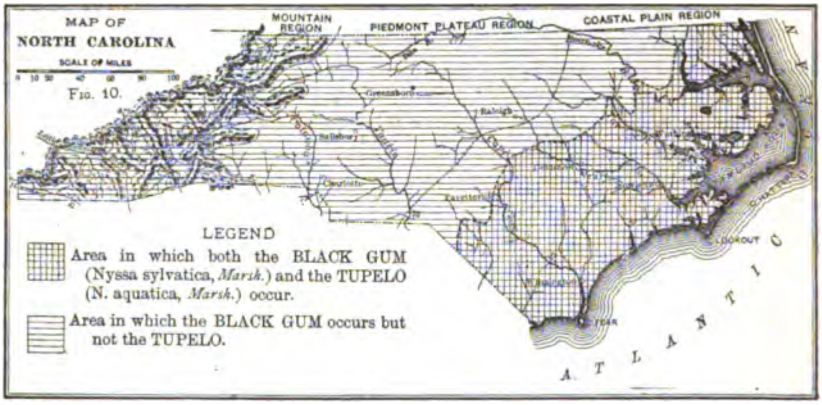

Fig. 10.

It produces seed plentifully once in two or three years, and young seedlings appear in moist open woods and on cypress lands after lumbering. Large trees are apt to be hollow at the butt and frequently through the whole stem. The black gum sprouts readily from the stump.

The rather thick shining leaves are oblong, pointed and usually entire. The greenish flowers, which appear after the leaves in spring, are inconspicuous, and the bluish-black oval fruit is about ½-inch long. The dark brown conical buds are slightly thicker than the smooth flexible twigs. The black gum has deeply seated lateral and numerous superficial roots.

The wood is heavy, strong, soft, very tough, and hard to split and work, inclined to check, and not durable in contact with the soil; light yellow or nearly white in color; the thick sapwood lighter, often hardly distinguishable. It is used for the hubs of wheels, rollers in glass factories, ox yokes, and piles.

Very little has been cut in this State for lumber. In the last few years, however, it has been coming into use as a cheap material for boxes and trucking barrels.

Nyssa aquatica, Marshall.

(TUPELO GUM.)

A large tree, with dark brown, deeply furrowed, or, in old specimens, scaly, smoothish bark, reaching a height of 100 and a diameter of 4 feet.

It occurs from southern Virginia to Georgia, through the Gulf states to Texas, and through Arkansas and southern Missouri to Illinois; reaching its best development in the cypress swamps of western Louisiana and southeastern Texas.

In this State it is confined to the deep swamps of the coastal plain, where it grows with cypress, water ash and black gum, attaining a height of 80 and a diameter of 4 feet above the trumpet-shaped base. (Fig. 10, p. 64.)

Seed years are frequent. Young trees are common along moist, deep swamps, in open woods, and in spots where the cypress has been removed. The large swollen butt, 8 to 15 feet in diameter, is usually hollow, and there is frequently also a hollow in the top of the stem, where a branch has been broken off. The middle of the trunk is nearly always sound.

The leaves are larger than in the preceding species, dark green and smooth above and somewhat downy below. The yellowish-green flowers appear in March and April. The oblong fruit is dark purple and an inch or more in length. The smooth light brown terminal buds are nearly round, the lateral buds minute. The twigs are slightly angular, light brown and smooth, and much thicker than those of the black gum. There are numerous lateral and superficial roots.

The wood is light, soft, not strong, close-grained, compact, unwedgeable, and light brown or nearly white in color. It is used for turning, woodenware, broomhandles, and wooden shoes. The roots are sometimes used as a substitute for cork for net floats. The wood has only a few local uses in North Carolina.

Oxydendron arboreum. De Candolle.

(SOURWOOD. SORREL TREE.)

A small tree, with pendulous branches and deeply furrowed gray-brown bark, reaching a height of 60 feet and a diameter of 20 inches.

It grows usually in rather dry soil, and occurs from western Pennsylvania along the Alleghany mountains to western Florida and Mobile bay, westward to middle Tennessee, and through the northern portions of the Gulf states to western Louisiana. It attains its best development in eastern Tennessee.

In North Carolina, where it reaches a height of 50 to 60 feet and a diameter of 12 to 15 inches, it is rare (and usually a shrub) in the coastal plain, not uncommon in the Piedmont plateau, and most abundant in the lower parts of the mountains. It reaches its largest size on the eastern slopes of the Blue Ridge.

The sourwood bears seed prolifically and for the most part every year. Young seedlings are usually very abundant, especially in rather dry woods which have been thinned. Sprouts grow readily from the stump, but do not attain a very large size. Trees over 10 inches in diameter are usually hollow.

The small rounded fruit is in large loose clusters. The oblong pointed leaves are acid, whence the name. The flowers and fruit occur in loose drooping panicles, 7 to 8 inches long. The red winter-buds are very small, and the flexible twigs are mahogany-red in color. The sourwood has numerous lateral roots. This tree is especially prized on account of the delicious transparent honey made from the flowers.

The wood is heavy, hard, very close-grained, compact, brown in color; the sapwood somewhat lighter. It takes a beautiful polish, and is used for the handles of tools, bearings of machinery, etc.

Kalmia latifolia, Linnæus.

(LAUREL. IVY. WICKY.)

A small evergreen tree, with short crooked branches, and dark reddish-brown furrowed bark, the narrow ridges separating into long scales. It reaches a height of 40 feet and a diameter of 20 inches.

It occurs in rich woodlands from New Brunswick and Lake Erie to western Florida, and through the Gulf states to western Louisiana and the valley of the Red river, Arkansas; reaching its best development in the southern Alleghany mountains, where it often forms dense impenetrable thickets.

In this State, where it grows to an average height of 10 to 15 feet, it is most abundant in the mountains, but occurs in the Piedmont plateau, and extends into the coastal plain region.

The laurel bears seed every year, and for the most part in abundance. Young seedlings, in all stages of growth, are common in moist open places in the mountain region, and above 3,000 feet on rather dry soil. The fires which are frequent on these dry ridges are very destructive to both young and old plants, but the laurel sprouts so freely from the stump that it often takes exclusive possession of areas subject to repeated fires.

The evergreen leaves are thick, smooth, entire, acute at the apex and contracted at the base. The white or pink flowers are produced in conspicuous clusters at the ends of the branches, and the rounded fruit set with sticky hairs is ripe in September. The winter-buds are small, oblong, and greenish. The roots consist of many large knots and burls, from which strong lateral roots diverge.

The wood is heavy, hard, strong, brittle, close-grained, and compact, brown in color; the sapwood somewhat lighter, and the broad medullary rays darker. It takes a good polish, and is used for the handles of tools, in turnery, and for fuel. The leaves, from which an ointment is made, are supposed to be poisonous to cattle. The root-burls, sometimes called ivy grubs, are used in turnery. Large quantities are taken out at Cranberry, Elk Park, and many other places in the mountain counties.

Rhododendron maximum, Linnæus.

(RHODODENDRON. LAUREL.)

A small tree, with spreading top and grayish-brown scaly bark, reaching a height of 40 feet and a diameter rarely exceeding twelve inches; or more frequently a tall straggling shrub.

It occurs from Nova Scotia and Lake Erie south through New England, New York, and along the Alleghanies to northern Georgia; reaching its best development on the steep rocky banks of streams in the southern Alleghany mountains. It is never found on limestone soils.

In North Carolina, where it grows to an average height of 8 to 12 feet, it is very common in the mountains, often forming impenetrable thickets, and occurs in ravines in the Piedmont counties as far east as Surry and Gaston.

Rhododendron usually produces seed every year, and young seedlings are common in moist open spots. Numerous sprouts appear around old trunks and around the stumps after cutting. Several stems generally grow from the same burly roots.

The thick leathery evergreen leaves are acute at the apex and narrowed toward the base. The flowers are pale rose-color or white, dotted with yellowish-green spots, and are produced in large compact clusters at the ends of the branchlets. The dark red-brown fruit is a dry capsule, half an inch long, and encloses many seeds. The buds are large, scaly and conical.

The wood is heavy, hard, strong, brittle, close-grained, compact, light clear brown in color; the sapwood lighter. It is occasionally employed in turnery, for tool handles, etc. A decoction of the leaves is used for rheumatism, sciatica, etc.

Diospyros virginiana, Linnæus.

(PERSIMMON.)

A small tree, with slender branches forming a rounded top and rough, dark brown, gray or black bark, reaching a height of 115 and a diameter of 2 feet.

It occurs commonly in old fields from southern Connecticut to southern Ohio and southeastern Iowa, south to Bay Biscayne, Florida, southern Alabama and Mississippi, and west to southern Missouri, Arkansas, eastern Kansas and Indian Territory, and the valley of the Colorado river, Texas; and reaches its best development in the lower Ohio basin.

In this State, where it reaches an average height of 30 to 40 feet and an average diameter of 18' to 20 inches, it is found throughout, except in Ashe, Watauga, Mitchell, and Yancey counties and in the higher mountains. (Fig. 11.)

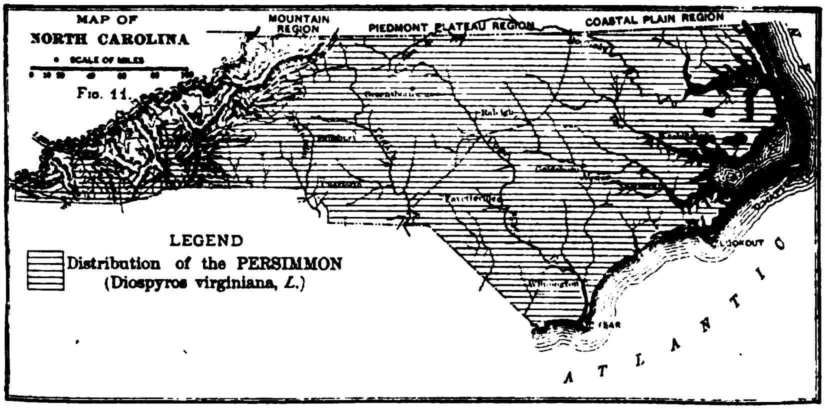

Fig. 11.

Fertile trees bear fruit in abundance annually or every second year. Seedlings are common near the old trees in damp soil, and in old fields when protected from fire. Young plants are short-lived in deep shade.

The rather thick smooth shining leaves are oval, dark green above, pale and often downy below. The yellowish flowers are small and inconspicuous, the male and female usually produced on separate trees. The edible fruit is rounded, about one inch in diameter, and orange-red when ripe. The winter-buds are small, egg-shaped and pointed. The persimmon has thick fleshy black stoloniferous roots; it has a taproot as well as numerous long lateral roots.

The wood is heavy, hard, strong, very close-grained, compact; the heartwood, seen only in very old specimens, dark brown to nearly black in color; the thick sapwood lighter brown with dark spots. It takes a good polish, and is used for shoe-lasts, plane stocks, shuttles, large screws, mallets and the shafts of wagons. A decoction for diarrhœa, hemorrhage, etc., is made from the fruit, from which persimmon beer is also produced.

Large quantities have been cut in North Carolina near the railroads.

Mohrodendron carolinum, Britton.*

(SNOWDROP TREE. SILVERBELL TREE.)

A tree of medium or small size, with reddish-brown, broadly ridged bark, and bright brown smooth branches striped with pale shallow longitudinal fissures, sometimes reaching a height of 90 and a diameter of 3 feet.

It occurs commonly in rich soil along streams from the mountains of West Virginia to southern Illinois, southward to middle Florida, central Alabama and Mississippi, and through Arkansas to western Louisiana and eastern Texas; reaching its best development in the southern Alleghany mountains.

In this State, where it reaches an average height of 15 to 25 feet, it is found in the Piedmont plateau as far east as Surry and Mecklenburg, and thence westward it is not uncommon, especially along the upper portions of the water courses.

The silverbell tree produces seed every two or three years and young plants are common in damp shady woods. Specimens over one foot in diameter are apt to be hollow.

The thin leaves are finely serrate, light green above, pale, and slightly downy below. The flowers, which appear with the leaves in spring, are white, bell-shaped, and are borne by slender drooping stems. The large dry fruit, about 1½ inches long, has four wings and contains a bony nut. The hairy winter-buds are small, obtuse, and dark red or light brown.

The wood is light, soft, close-grained, compact, light brown in color; the sapwood lighter. It has no uses in North Carolina.

Fraxinus americana, Linnæus.

(WHITE ASH.)

A large tree of the first commercial value, with stout, upright

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*Halesia tetraptera, Linnæus.

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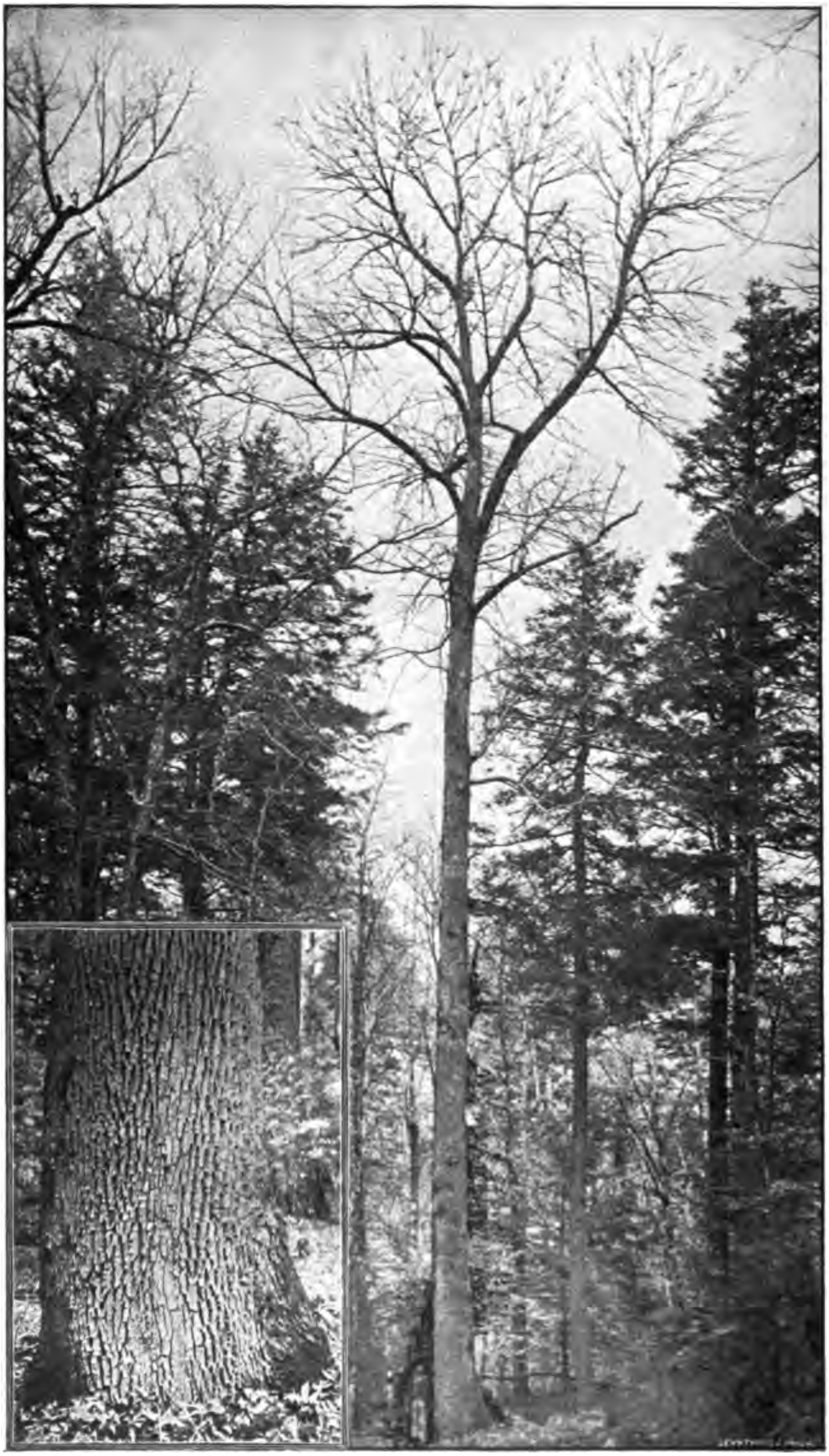


WHITE ASH

or spreading branches and grayish furrowed bark, reaching a height of 120 and a diameter of 6 feet. (Plate VI.)

It grows in low, rather moist soil, from Nova Scotia to northern Minnesota, southward to northern Florida, central Alabama and Mississippi, and west to eastern Nebraska, Kansas, Indian Territory, and eastern Texas; reaching its best development in the basin of the Ohio river.

In North Carolina, where it grows to an average height of 50 to 80 and a diameter of 2 to 3 feet, it occurs throughout the State. (Fig. 12.)

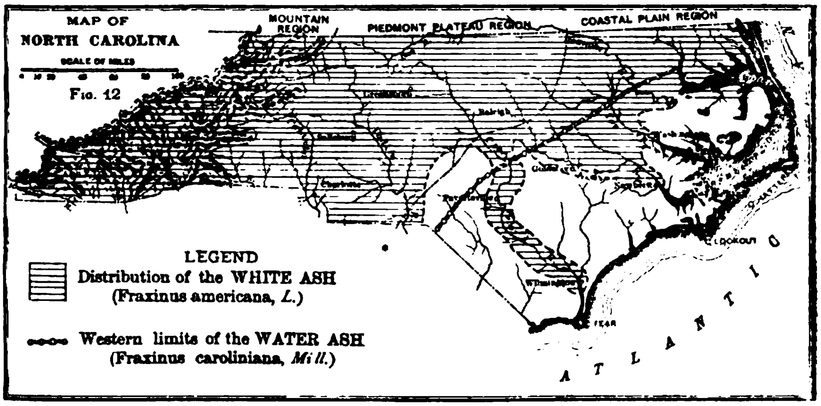


FIG. 12

The white ash produces seed abundantly about every 3 or 4 years, though individual trees along streams, or when isolated, bear more frequently. The young seedlings, which are not common, stand shade well, and are usually found in moist situations, often at a considerable distance from the parent tree. Large trees are usually sound, but sometimes have large heart-cracks. In the mountains a mixed growth of oaks, lin, and buckeye replace the white ash after lumbering. The timber is attacked while still standing, especially when growing in swamps, by Fatua dennudata, Harris, the ash sesia.

The leaves are composed of 5 to 9, usually 7, stalked leaflets. The inconspicuous flowers appear before the leaves in spring, the male and female on separate trees, and the narrow-winged fruit is 1½ to 2 inches long. The rust-colored winter-buds are covered with short hairs. The ash has numerous deep-seated lateral roots.

The wood is heavy, hard, strong, coarse-grained, tough, becoming brittle with age; the heartwood brown; the sapwood nearly white. It is extensively used for agricultural implements, wagon-making, handles, oars, cabinet and interior work, and by shipwrights, turners, and coopers.

Large quantities have been sawed in the mountains of this State, chiefly for lumber and furniture. Asheville, Dillsboro, and Elk Park are important centres for the manufacture of ash lumber. In 1892 about 8,000,000 feet was sawed in the mountain counties and shipped mainly to Cincinnati and Philadelphia. About as much more was manufactured during the same year in other parts of the State. A large amount of white ash is still standing in the mountain region and in some of the river swamps of the eastern counties.

Fraxinus pennsyvanica, Marshall.

(RED ASH. ASH.)

A tree of medium size, with stout, upright branches and slightly furrowed dark gray or deep brown bark, reaching a height of 60 feet and a diameter of 20 inches.

It occurs in rich moist ground from New Brunswick to southern Ontario and northern Minnesota, and southward to northern Florida and central Alabama; attaining its best development in the northern Atlantic states. It is rare west of the Alleghany mountains.

In this State, where it grows to a height of 50 to 60 feet, it is confined to the Piedmont plateau.

The red ash produces seed about as often as the white ash, but seedlings are less common and confined principally to the neighborhood of water courses. Numerous sprouts spring up after cutting, but do not develop into large trees. Birch, white oak and red maple usually form the growth after lumbering.

The leaflets are 7 to 9 in number, obscurely toothed, narrowed at the apex into long, slender points, lustrous on the upper surface, and downy beneath; the leafstalks also covered with a silky down. The male and female flowers appear on separate trees late in spring, and the narrow-winged fruit is like that of the white ash, except that the end of the wing is usually more rounded. The dark, russet-brown rounded winter-bud is downy. The red ash has numerous lateral and superficial roots.

The wood is heavy, hard, strong, brittle, close-grained and compact, rich brown in color; the sapwood light brown streaked with yellow. It is used for paper pulp and for the same purposes as that of the white ash, to which it is inferior.

Fraxinus pennsylvanica var. **lanceolata**, Sargent.

(GREEN ASH. ASH.)

A tree of medium size, with slender, spreading branches and gray or dark brown bark, rarely exceeding 60 feet in height and 24 inches in diameter.

It occurs in low, rather moist soil, from Vermont to northern Florida, westward to the valley of the Saskatchewan river and the Rocky mountains of Montana, the Wasatch mountains of Utah and the eastern and northern ranges of Arizona. It is most abundant in the Mississippi basin.

It is not a common tree in North Carolina, and is confined to the upper part of the coastal plain and to the Piedmont plateau, where it reaches a height of 60 and a diameter of 2 feet.

The leaflets are smooth and bright green on both sides, and narrower, shorter, and often more sharply toothed than those of the red ash. In the West the species and variety are connected by many intermediate forms. East of the Mississippi river the trees are quite distinct.

The wood is heavy, hard, strong, brittle, rather coarse-grained; brown in color; the thick sapwood lighter. It is inferior in quality to the wood of the white ash, but in this State is not distinguished from it commercially.

Fraxinus caroliniana, Miller.

(WATER ASH.)

A small tree, with slender branches which form a narrow top, and light gray furrowed bark, reaching a height of 40 feet and a diameter of 12 inches.

It occurs in deep river swamps from southeastern Virginia near the coast to Florida, westward through the Gulf states to the valley of the Sabine river, Texas, and southwestern Arkansas. It is also found in Cuba.

In North Carolina, where it reaches an average height of 30 to 40 feet, it is confined to the deep swamps of the coastal plain region. (Fig. 12, p. 71.)

It bears seed abundantly every year or two. Trees in deep swamps have swollen butts which are usually hollow, but as a general rule the upper part of the stem is sound.

The leaves are composed of from 5 to 7 large, long-stalked leaflets. The male and female flowers appear in February and March upon separate trees. In the fruit the wings extend to the bottom of the seed, and are sometimes three in number. The winter-buds are chestnut-brown in color. The water ash has numerous deeply seated lateral roots.

The wood is light, soft, not strong, brittle, close-grained, and compact; the heartwood nearly white, sometimes tinged with yellow; the sapwood lighter. It is of less value than that of many of the other ashes.

In the eastern section of North Carolina it is largely manufactured into lumber. The best logs are usually sawed into furniture squares.

Persea borbonia, Sprengel.

(RED BAY. SWEET BAY.)

An evergreen tree, with dark brown-green branches and deeply furrowed reddish bark, reaching a height of 70 and a diameter of 3 feet.

It occurs in low rich soil from southern Delaware south to Bay Biscayne and Cape Romano, Florida, and through the Gulf states to southern Arkansas and the valley of the Brazos river, Texas, near the coast.

In this State it is a small tree or shrub, and occurs in the coastal plain region. Old trees over 8 inches in diameter are frequently hollow.

The oblong entire evergreen leaves are 2 to 3 inches long and, like the twigs, have an aromatic odor when bruised. The flowers are small and in close panicles, and the fruit is an ovate 1-seeded deep blue drupe. The small dark brown winter-buds and dark twigs are downy. The red bay has a lateral root system.

The wood is heavy, hard, very strong, brittle, very close-grained, and compact; bright red in color; the sapwood much lighter. It takes a beautiful polish, and was formerly somewhat used in ship-building, interior finish and cabinet work.

Sassafras sassafras, Karsten.

(SASSAFRAS.)

A large tree, with green or yellowish-green branchlets and furrowed gray bark. It sometimes reaches a height of 90 and a diameter of 7 feet, but is reduced to a shrub at its northern limit.

It occurs from eastern Massachusetts and southwestern Vermont, west through southern Ontario and central Michigan, to southeastern Iowa, eastern Kansas, and Indian Territory, and south to middle Florida and the valley of the Brazos river, Texas; reaching its best development in southwestern Arkansas and Indian Territory.

In this State, where it rarely exceeds 40 to 50 feet in height, it is most common in the coastal plain and Piedmont plateau regions, and rare on the higher slopes of the mountains.

Seed is produced at frequent intervals, and young seedlings are common in old fields when protected from fire. Sprouts spring readily from the stumps of young trees and from the spreading roots, and in many cases become large trees.

The leaves are very variable, being ovate and entire, or 2 to 3-lobed. The greenish-yellow clustered flowers appear in early spring, the sterile and fertile on separate trees, and the oval fruit is blue in color, with a thick reddish stem. The egg-shaped winter-buds are large.

The wood is light, soft, weak, brittle and coarse-grained, very durable in contact with the soil, and apt to check in drying. It is slightly aromatic. The heartwood is dull orange-brown in color; the thin sapwood light yellow. It is used in boat building, fencing, cooperage, and for ox yokes. An aromatic stimulant is derived from the bark of the root.

Ulmus americana, Linnæus.

(AMERICAN ELM.)

A large tree, with short spreading or long pendulous branches and scaly dark brown trunk, reaching a height of 120 and a diameter of 11 feet.

It occurs in rich moist soil from southern Newfoundland to the northern shores of Lake Superior and the eastern slope of the Rocky mountains, south to Florida, and west to Dakota, central Nebraska, Indian Territory, and Texas; reaching its best development in the northeastern United States.

In this State, where it reaches an average height of 60 to 70 and diameter of 4 to 5 feet, it occurs abundantly in most of the swamps of the coastal plain and extends westward as far as Guilford and Mecklenburg counties. (Fig. 13.) It is smaller and much less common toward its western limit.

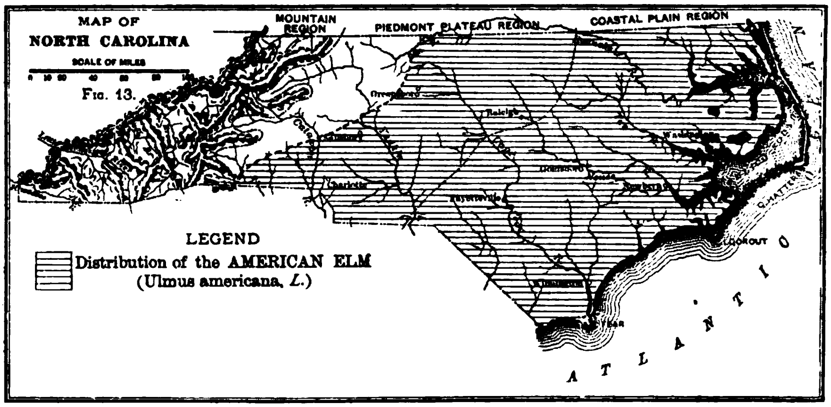


Fig. 13.

Seed is borne generally every year in abundance, and young plants are common in damp open places. The American elm does not sprout readily from the stump.

A larva of a longicorn beetle, Saperda tridentata, Oliver, loosens the inner bark and channels the surface of the wood so as frequently to kill the tree. The American elm also suffers severely from canker-worms, Paleacrita vernata, Peck, and Eugonia subsignaria, Huebner, and the imported elm-leaf beetle, Galeruca scanthomelæna, Schrank, all of which feed upon and destroy the foliage.

The leaves are usually smaller and less rough than those of the slippery elm. The small greenish-brown flowers are in numerous lateral clusters and appear early in spring. The flattened oval winged fruit is hairy on the margin, and ripens and falls before the leaves appear. The buds are smooth, rather small and acute. The American elm has long, well developed lateral roots.

The wood is heavy, hard, strong, tough, rather coarse-grained, compact, and difficult to split; the heartwood light brown; the sapwood lighter. It is used for wheel stocks, saddle-trees, flooring, and cooperage, and is exported for boat and ship-building.

In North Carolina the wood of this tree is not much used, and very little of it has ever been cut.

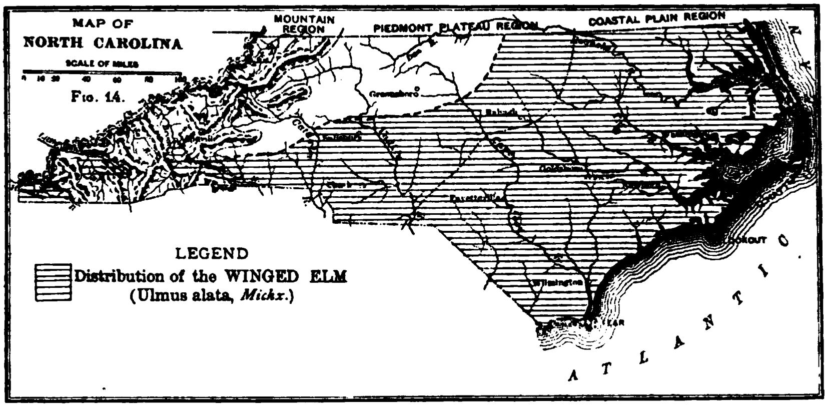
Ulmus alata, Michaux.

(WINGED ELM. WAHOO. CORK ELM. SOUTHERN ELM.)

A small tree, with slender branches and close finely ridged light brown bark, reaching a height of 50 and a diameter of 2 feet.

It occurs on dry gravelly or often on moist soil from southern Virginia, through the middle districts to western Florida, southern Indiana and Illinois, south to the Gulf coast, and southwest through southern Missouri, Arkansas, and the eastern portion of Indian Territory and Texas; reaching its best development in southern Missouri and Arkansas.

In this State, where it reaches an average height of 30 to 45 feet, it grows along swamps and streams, and is nowhere uncommon except on the mountains. (Fig. 14.)



The winged elm bears seed abundantly at intervals of 2 or 3 years, and young plants are frequent along streams or swamp land.

The leaves are smaller than those of the American elm and the brown twigs more slender. The small clustered flowers are on slender foot-stalks, and the oval winged fruit is deeply notched, and hairy on the margin. There are numerous long superficial lateral roots.

The wood is heavy, hard, not strong, very close-grained, compact, unwedgeable; brown in color; the sapwood lighter. It is used for hubs, blocks, and tool handles.

Ulmus fulva, Michaux.

(SLIPPERY ELM.)

A tree, with deeply furrowed dark brown bark and dark gray-brown branches which form a broom-shaped crown, reaching a height of 135 and a diameter of 4 feet.

It occurs in rich soil from the valley of the lower St. Lawrence river to northern Dakota, and south to northern Florida, central Alabama and Mississippi, and the valley of the San Antonio river, Texas.

In this State, where it reaches an average height of 30 to 50 feet and a diameter of 12 to 18 inches, it is most plentiful in the Piedmont plateau, less so among the mountains, and is found occasionally in the coastal plain region.

The slippery elm produces seed at rather irregular intervals of 2 to 4 years, and for the most part not abundantly. Young seedlings are rare except in damp, somewhat shaded places near the parent tree.

The thick ovate oblong coarsely toothed leaves are very rough on the upper surface and downy beneath. The flowers occur in lateral clusters on short foot-stalks, and the flat-winged fruit is round, but not fringed. The rounded reddish-brown winter-buds are hairy. The slippery elm has numerous deeply seated lateral roots.

The wood is heavy, hard, strong, very close-grained, compact, and durable in contact with the soil. The heartwood is dark brown or red; the sapwood lighter. It is used for wheel-stock, fencing, railroad ties, sills, and in shipbuilding. The mucilaginous inner bark is medicinal.

Morus rubra, Linnæus.

(RED MULBERRY.)

A tree, with dark brown, much-broken bark and smooth gray branches, reaching a height of 65 and a diameter of 7 feet.

It is found generally in rich soil from western Massachusetts and Long Island, N. Y., through southern Ontario, central Michigan, and the Black Hills of Dakota, eastern Nebraska and Kansas, south to southern Florida, and the valley of the Colorado river, Texas; reaching its best development in the basins of the lower Ohio and Mississippi rivers.

In this State, where it grows to an average height of 30 to 50 and an average diameter of 1 to 2 feet, it is found throughout, being most abundant on the Piedmont plateau and very rare in the mountain region.

The red mulberry bears large quantities of seed every year or every other year, and seedlings are found on moist soil through the forests of the Piedmont plateau region. Numerous sprouts come up after cutting.

The broad, heart-shaped, pointed leaves are rough above and downy below. The flowers are inconspicuous, and the deep red or purple fruit is sweet and edible, with an agreeable, slightly acid taste. The winter-buds are large, reddish, smooth and conical.

The wood is light, soft, not strong, rather tough, coarse-grained, compact, very durable in contact with the soil, light orange-yellow in color; the sapwood lighter.

It takes a good polish, and is largely used for fencing, cooperage, snaths, and, at the South, for ship and boatbuilding. The leaves have been used for feeding silkworms, but are not well adapted for that purpose.

Celtis occidentalis, Linnæus.

(HACKBERRY.)

A large tree, with bark often much roughened by small ridges, and flexuous, smooth, brown branches. It reaches a height of 130 and a diameter of 5 feet, or sometimes is reduced to a low shrub.

It occurs in rich bottoms or on dry hillsides from the valley of the St. Lawrence river west to eastern Dakota, south through the Atlantic region to southern Florida, and to Texas; being most abundant and reaching its best development in the basin of the Mississippi river.

In this State, where it reaches an average height of 50 to 70 feet and a diameter of 18 to 20 inches, it is found throughout, except in the high mountain counties, as Ashe, Watauga, Mitchell, and Yancey, and attains its greatest size and abundance in the alluvial swamps of the coastal plain.

It bears seed plentifully and as a rule every year. Seedlings are common near old trees and along river bottoms.

The leaves are ovate, toothed, taper-pointed, and smooth at maturity. The greenish flowers are inconspicuous, and the rounded, purplish-red fruit, from ¼ to ⅓ inch in diameter, is sweet and edible.

The wood is heavy, rather soft, not strong, coarse-grained, compact, clear light yellow in color; the sapwood, lighter. It takes a good polish, and is largely used for fencing, and occasionally in the manufacture of cheap furniture.

Platanus occidentalis, Linnæus.

(SYCAMORE. BUTTONWOOD.)

A large tree, with deep brown smooth bark, scaling off in thin, brittle plates, leaving the tree a mottled polished white, or with bark uniform and rough. It reaches a height of 130 and a diameter of nearly 14 feet.

It occurs in rich moist soil, generally near streams, from southern Maine and the northern shores of Lakes Ontario and Erie west to eastern Nebraska and Kansas, south to northern Florida, central Alabama, Mississippi, and southern Texas; reaching its best development in the bottom lands of the Ohio and Mississippi rivers. It is a very common tree.

In this State, where it reaches a height of 90 and a diameter of 5 or 6 feet, it occurs throughout, growing to its best size along the alluvial swamps of the Piedmont plateau. It is least abundant on the coastal plain.

The sycamore bears fruit in abundance and usually every year, and seedlings are common along streams. Old trees are generally hollow at the butt. It sprouts very freely from the stump, and is easily propagated from cuttings. The growth is very rapid.

The large broad leaves are angularly lobed and toothed, downy when young, and smooth at maturity. The male and female flowers occur in separate small spherical heads with slender stems. The fruit is a globular head one inch in diameter, hanging on the tree through the winter. The short, broad, pyramidal buds are formed beneath the swollen base of the leafstalks. The sycamore has numerous long running roots.

The wood is heavy, hard, not strong, very close-grained, compact, difficult to split and work; brown in color; the sapwood lighter. It decays rapidly in contact with the soil or on exposure, and warps and cracks badly in drying. It is used for ox yokes, butchers' blocks, for interior finish, and in the manufacture of furniture, and very largely for tobacco boxes.

Juglans cinerea, Linnæus.

(WHITE WALNUT. BUTTERNUT.)

A large tree, with dark granite-gray furrowed bark and light gray smoothish branches, reaching a height of 115 and a diameter of 3 feet.

It occurs in rich woodlands, from southern New Brunswick, the valley of the St. Lawrence river and Ontario, to Dakota and Nebraska, southward to Delaware, Missouri, and Arkansas, and along the Alleghany mountains to Georgia and Alabama; reaching its best development in the basin of the Ohio river.

In North Carolina it occurs through the mountains and sparingly through the upper part of the Piedmont plateau, but is nowhere common. In certain cool, rich mountain valleys it attains a height of 70 and a diameter of 3 feet. (Fig. 15, p. 83.)

The white walnut bears fruit abundantly only every 2 or 3 years, and young seedlings are uncommon. Young trees sprout freely from the stump; old ones less readily.

The leaflets are 11 to 17 in number on the sticky leafstem, rounded at the base, taper-pointed, sharply toothed, and downy on the lower surface. The sterile flowers are in large green catkins, the fertile flowers small and inconspicuous. The brown fruit is 2 to 3 inches long, very sticky, and contains an edible nut. The naked winter-buds are light brown, blunt, and covered with soft down; the terminal buds large and conspicuous, the lateral buds much smaller, two or three together above each leaf-scar. There are numerous strong superficial lateral roots, while the taproot in specimens over 10 inches in diameter is poorly developed.

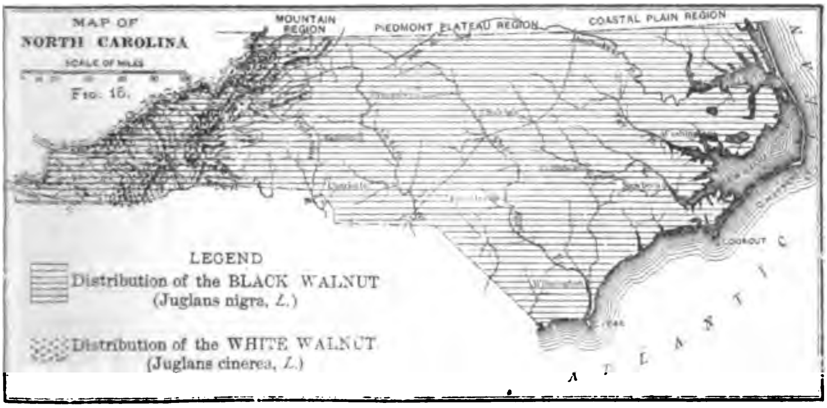
The wood is light, soft, not strong, coarse-grained, compact, and easily worked; light brown in color; the sapwood, lighter. It takes a beautiful polish, receives paint well, and is used for interior finish, cabinet work, panels of carriages, and occasionally for the lower framework of buildings. The inner bark yields a yellow dye, and is employed as a mild cathartic.

Juglans nigra, Linnæus.

(BLACK WALNUT.)

A large tree, of the first commercial value, with a small oval crown and rough very dark brown bark, reaching a height of 150 and a diameter of 10 feet or more.

It occurs from western Massachusetts to eastern Nebraska and Kansas, and south to northern Florida, Alabama, Mississippi, and the valley of the San Antonio river in Texas; reaching its best development in the rich bottom lands of southwestern Arkansas and Indian Territory, and on the western slopes of the southern Alleghany mountains.



In this State, where it grows to an average height of 40 to 50 feet, it is most abundant on the Piedmont plateau, but is found throughout. (Fig. 15.)

Forest trees bear seed abundantly only every 3 or 4 years, and young seedlings are not common except near mature trees in low fertile rather open lands or in fields and meadows which border streams. The growth is very rapid until a large size is reached, especially when the soil is good and the light conditions favorable. Only small trees send up from the stump shoots, which attain a large size.

The leafstalk is slightly downy but not sticky; the leaflets 15 to 23 in number, smooth above and somewhat downy beneath. The fruit is round, greenish-yellow when ripe, about 2 inches in diameter, and contains a nut with an edible kernel. The large terminal buds are covered with a light brown tomentum and the lateral buds are above the leaf scars as in the preceding species. The black walnut has a well-developed taproot and numerous strong lateral roots.

The wood is heavy, hard, strong, rather coarse-grained, liable to check, easily worked, and durable in contact with the soil; rich dark brown in color; the thin sapwood much lighter. It takes a beautiful polish, and is used for cabinet making, interior finish, gunstocks, and in boat and shipbuilding. The husk of the fruit yields a dye.

The black walnut has been largely removed from the counties west of the Blue Ridge, where it reaches its largest size in this State. Considerable quantities are still standing, however, in the Piedmont region, and in the coastal plain region it has not yet been entirely removed.

Hicoria minima, Britton.*

(BITTERNUT HICKORY. RED-HEART HICKORY.)

A tall and slender tree, with a broadly pyramidal crown, rather smooth, firm, gray bark, and lighter smoother branches, reaching a height of 120 and a diameter of 4 feet.

It occurs from southern Maine to the valley of the St. Lawrence river, westward through Ontario, central Michigan and Minnesota, and the eastern parts of Nebraska, Kansas, and Indian Territory, and southward to western Florida and eastern Texas; reaching its best development in Pennsylvania and Ohio.

In North Carolina it grows to an average height of 80 and a diameter of 2 to 3 feet, and occurs in moist, cool situations, on loamy or clay soils in all parts of the State, but is abundant only in the mountains, where it is the largest and most common hickory.

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*Carya amara, Nuttall.

The fruit is borne plentifully at short intervals, and seedlings are frequent in the mountains, especially in moist open woods.

The leaves consist of 5 to 9 small, narrow, acute, smoothish leaflets. The dark green fruit is rounded or slightly egg-shaped, with a very thin husk, opening half way down when ripe. The shell of the white, smooth nut is so thin that it can be broken with the fingers. The kernel is intensely bitter. The yellow winter-buds are small, elongated, and slightly rounded or pointed.

The wood is heavy, very hard, strong, and tough, and checks badly in drying; dark brown in color; the sapwood lighter, or often nearly white. The wood is inferior to that of the other hickories, but is used for hoops, ox yokes and fuel.

Hicoria aquatica, Britton.

(WATER-BITTERNUT HICKORY. WATER HICKORY. SWAMP HICKORY.)

A tree, with rough, somewhat furrowed bark, reaching a height of 100 and a diameter of 3 feet, or generally much smaller.

It occurs from Virginia through the coast region to Florida, along the Gulf shore to Texas, and northward to southern Illinois; reaching its best development on the lower Mississippi and Yazoo rivers.

In this State, where it is confined to the coastal plain, it grows to an average height of 40 to 50 feet. (Fig. 16, p. 86.)

Young seedlings are uncommon in this State, and are found only on alluvium, and then usually in spots where trees have been cut.

There are 7 to 13 smooth, pointed, slightly toothed leaflets. The fruit is roundish, with a thin husk 4-parted to the base. The thin-shelled, 4-angled nut contains a very bitter kernel. The flattened winter-buds are covered with a rusty down. The water-bitternut hickory has a poorly developed taproot and numerous strong lateral roots.

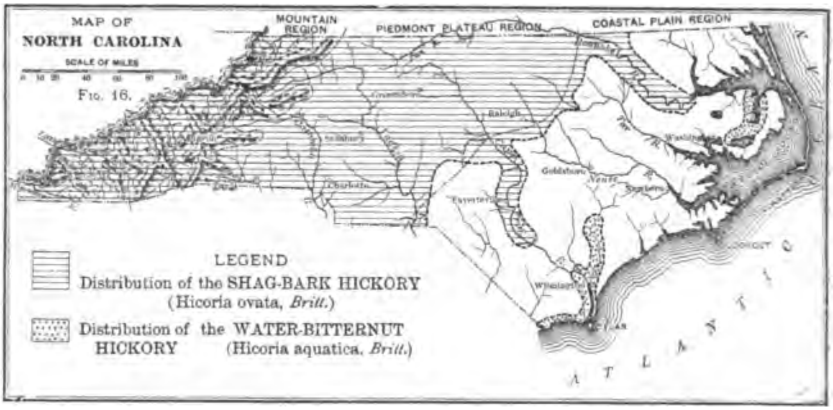
The wood is heavy, soft, strong, rather brittle, very close-grained, and compact; the heartwood, dark brown; the sapwood lighter, often nearly white. The timber is of an inferior quality, and is chiefly used for fencing and fuel. It is rare in North Carolina, and, from the difficulty in getting it out of the swamps, it is little used.

Hicoria ovata, Britton.

(SHAG-BARK HICKORY. SHELL-BARK HICKORY. SCALY-BARK HICKORY.)

A large tree of great commercial value, with pendulous branches, and grayish-brown bark separating from the trunk in long strips. It reaches a height of 150 and a diameter of 4 feet.

It occurs on rich hillsides and on sandy ridges from the valley of the St. Lawrence river to Michigan and southeastern Minnesota, southward to western Florida, central Alabama and Mississippi, and westward to eastern Kansas, Indian Territory, and eastern Texas; reaching its best development west of the Alleghany mountains. A common tree.



In this State, where it attains an average height of 60 to 80 feet and an average diameter of 15 to 20 inches, it occurs throughout but is nowhere common, and least so in the coastal plain region. (Fig. 16.)

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* Carya alba, Nuttall.

Seed is borne frequently and in large quantities, but seedlings are not common except in the Piedmont plateau, and young trees are infrequent in second-growth woods.

The leaves are large and composed of 5 to 7-pointed, rather coarsely toothed leaflets, the lower pair small and narrow, the upper pair and terminal leaflet very large, broad and inversely egg-shaped. The barren flowers are in slender, pendulous, green tassels, three on a common stalk. The minute fertile flowers are in groups of 2 to 4 together on the ends of the shoots. The thick husk of the nearly globular fruit separates into four distinct pieces, and the nut is white, sweet, edible, and 4-angled. The large, yellowish-brown, scaly buds are egg-shaped.

The shag-bark hickory has numerous lateral roots and a strong taproot which is developed in early youth.

The wood is heavy, very hard and strong, tough, close-grained, compact, and flexible; light brown in color; the thin and more valuable sapwood nearly white. It is largely used for agricultural implements, carriages, axe and tool handles, baskets and fuel.

Hicoria alba, Britton.*

(WHITE HICKORY. BIG-BUD HICKORY. MOCKERNUT.)

A tree, with dark ashen-gray, deeply furrowed bark, reaching a height of 108 and a diameter of 4 feet.

It occurs from southern Ontario to the eastern parts of Nebraska, Kansas, and Indian Territory, southward to central Florida and the valley of the Brazos river, Texas. It grows on rich hillsides or in low river bottoms, and is very common in the Gulf states and throughout the South.

In North Carolina, where it grows to an average height of 60 feet and a diameter of 18 to 20 inches, it is common throughout the State. (Fig. 17, p. 88.)

The white hickory bears fruit frequently and in abundance. Seedlings are common near old trees and in second-growth woods, and often in dry or moist uplands a considerable part of the forest is composed of young trees of this species. Yuong trees, when cut down or killed by fire, send up numerous sprouts from the stump. Late spring frosts are very injurious to this species, frequently checking the growth of the new twigs and at times killing the tree.

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*Carya tomentosa, Nuttall.

The leaves are very large and consist of 7 to 9 leaflets, the lower surface of which, as well as the recent shoots and leafstems, are downy when young. The fruit is oval, nearly round or slightly pear-shaped, and 1½ to 2 inches or more in length. The husk splits nearly to the base when ripe. The thick-shelled, somewhat 6-angled nut contains a small and unusually sweet kernel. The winter-buds are large, round, and covered with downy, hard, grayish-white scales.

The wood is heavy, very hard, strong, tough, very close-grained, and flexible, and checks in drying. The heartwood is rich dark brown; the thick sapwood nearly white. It is used for the same purposes as the wood of the shag-bark hickory. (Page 86.)

Hicoria glabra, Britton.

(PIGNUT.)

A large tree, with an oval head and firm, close, rough, gray bark on the trunk, and smoother, lighter bark on the branches. It reaches a height of 130 and a diameter of 5 feet.

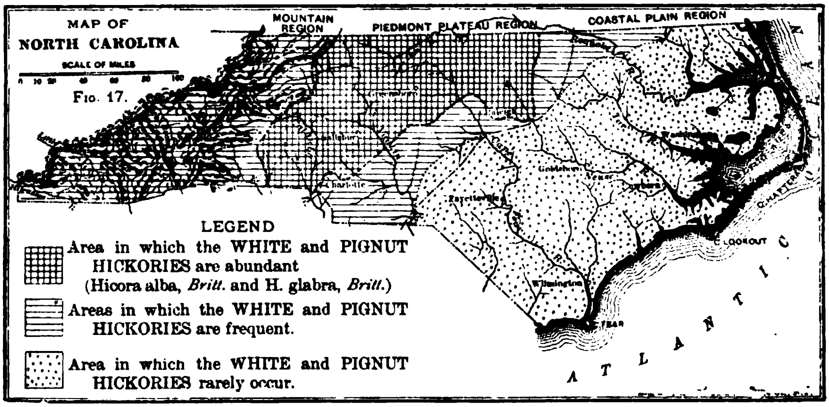
MAP OF
NORTH CAROLINA
SCALE OF MILES
0 10 20 40 60 80 100
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
Charlotte
Fayetteville
Goldsboro
Wilmington
LOOKOUT
FEAR
ATLANTIC
LEGEND
Area in which the WHITE and PIGNUT HICKORIES are abundant (Hicora alba, *Britt.* and H. glabra, *Britt.*)
Areas in which the WHITE and PIGNUT HICKORIES are frequent.
Area in which the WHITE and PIGNUT HICKORIES rarely occur.

FIG. 17.

It occurs on dry hills and uplands from southern Maine to southern Ontario, southern Michigan, Minnesota, the eastern parts

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WHITE OAK

of Nebraska, and Indian Territory, and south to western Florida and southern Texas; reaching its best development in the lower Ohio basin.

In this State, where it reaches an average height of 70 to 80 feet, it is found throughout. It is not a common tree in the mountains, and is rare in the coastal plain region; but along with the white hickory it is fairly abundant in the Piedmont plateau region. (Fig. 17, p 88.)

The pignut bears fruit frequently and in large quantities, and young growth is common near the parent trees and through second-growth woods.

The leaves are long, with 5 to 7 smooth leaflets. The smooth, tapering twigs are smaller than in the two preceding species. The fruit is pear-shaped or rounded, with very thin husks splitting about halfway to the base. The rather thin-shelled nut, about ½ inch in diameter, contains a small sweetish or slightly bitter kernel. The polished brown winter-buds are egg-shaped and pointed or rounded It has numerous lateral roots and a taproot which is developed early in the life of the tree.

The wood is heavy, hard, very strong, and tough, flexible and close-grained, and checks in drying; dark or light brown in color; the thick sapwood lighter, often nearly white. Its uses are the same as those of the shag-bark hickory, to the wood of which species for some purposes it is preferred.

Quercus alba, Linnæus.

(WHITE OAK.)

A large tree, of great economic value, with large spreading branches and a bark which is either light gray, slightly roughened, and in the older trees, loosens in large thin scales, or is gray, firm, and deeply furrowed. It reaches a height of 150 and a diameter of 8 feet. (Plate VII.)

It occurs on all soils from northern Maine to the valley of the St. Lawrence, westward through lower Michigan to southeastern Minnesota, and southward to St. John's river and Tampa bay, Florida, and the valley of the Brazos river, Texas; reaching its best development on the slopes of the Alleghany mountains, and in the valley of the Ohio river and its tributaries. It is a common tree in a considerable portion of the central and eastern states.

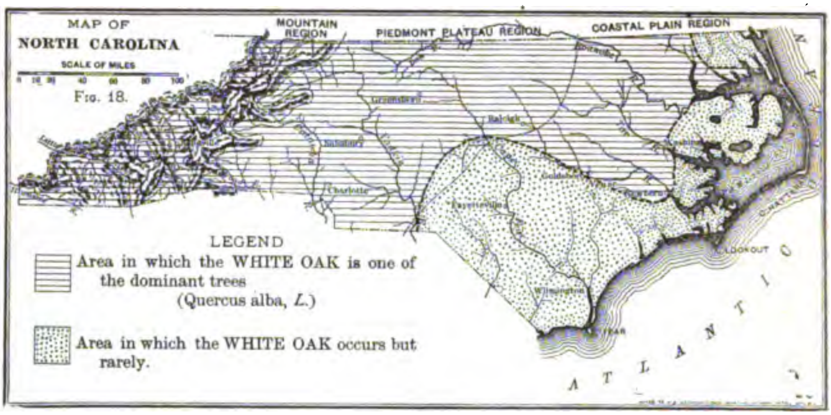


Fig. 18.

In North Carolina, where it attains an average height of 70 to 80 and an average diameter of 4 to 5 feet, it occurs throughout, and is common everywhere except in the northeastern part of the State and on the sandy soils of the southeastern section. It is most plentiful on the Piedmont plateau. (Fig. 18.)

Large quantities of seed are produced about once in three years. The acorns germinate in all kinds of soil and frequently seed up old fields. Young seedlings are common in all situations, and bear well either the deep shade of the old tree or full exposure to the sun. Young white oaks are apt to form a large part of the new growth after the removal of the yellow poplar, short-leaf pine or the white oak itself. In many parts of the original forest, on poor soil, white oak is the predominant tree, and it generally forms a large part of second growth of mixed hardwoods. Small trees sprout freely and vigorously from the stump. Individuals over 3 inches in diameter are not easily killed by fire. Large trees are rarely hollow. Though a large number of insects live on the white oak, it is not seriously injured by borers or insects which attack the leaves or twigs. A weavil frequently destroys the acorns.

The leaves are acute at the base, with 7 to 9 blunt, rounded, usually entire lobes. The male flowers are in long slender threads, the female very minute. The acorns, usually in pairs, have rounded saucer-shaped, rough, warty cups, and brown, sweet, edible nuts. The small blunt winter-buds are smooth, as are the light brown or gray slender twigs. The white oak has a taproot and numerous deeply seated lateral roots.

The wood is strong, very heavy, hard, tough, close-grained, liable to check, and very durable in contact with the soil; brown in color; the sapwood lighter. It is used for shipbuilding, construction, cooperage, carriages, agricultural implements, railway ties, fencing, interior finish, cabinet-making, baskets, fuel, etc. It is altogether one of the most important timbers of the United States.

In North Carolina it is largely used for fuel, clapboards, fencing, ties, and staves. It has been manufactured into lumber for local uses only. Large quantities of merchantable timber still stand in the mountain counties and in many of the counties of the Piedmont plateau. The bark is used extensively for tanning, but is less highly valued than that of the chestnut oak.

Quercus minor, Sargent.

(POST OAK.)

A tree, with rough hard gray bark, and numerous spreading branches, reaching a height of 100 and a diameter of 5 feet; or on the Florida coast reduced to a low shrub.

It occurs generally in poor soil from Massachusetts south to northern Florida, and west through southern Ontario and Michigan to eastern Nebraska, Kansas, and Indian Territory, and into central Texas, and is very common in the Gulf states west of the Mississippi.

In this State, where it grows to a height of 50 and a diameter of 4 feet, it occurs in greatest numbers and attains its largest size in the Piedmont counties. Here it forms with the white oak a large part of the second-growth in the forest and in old fields. It is not common in the transmontane counties. In the eastern section it frequently forms, on the margins of swamps, a lower story beneath the willow and water oaks. (Fig. 19, p. 92.)

The post oak bears fruit abundantly every 2 or 3 years, and young plants are common in thinned and second-growth woods, bearing well both deep shade and strong light. It does not sprout as freely as white oak. Although in favorable situations the growth is rapid, in general it grows more slowly than the white oak.

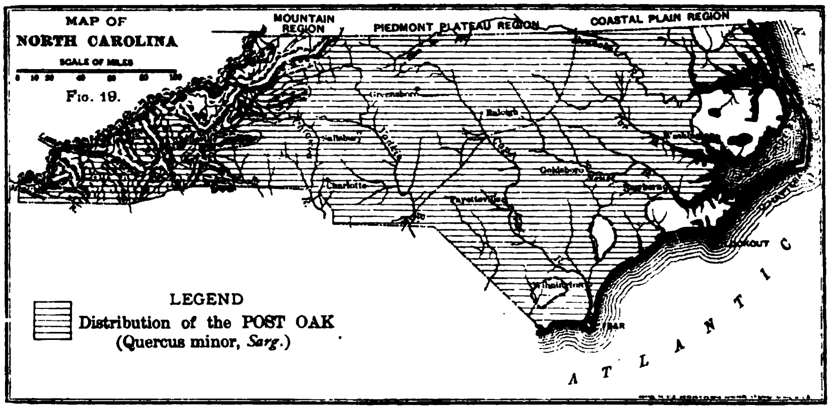


Fig. 19.

The leaves are stiff, leathery, rough above, whitish and downy below, and divided into 5 to 7 roundish divergent lobes, the upper lobe large and often double. The acorns, borne on short foot-stalks, are small and sweet, and seated in deep, grayish, smooth-scaled cups. The winter-buds are small, rounded, smooth, and dark brownish-red.

The wood is heavy, hard, close-grained, compact, checks badly in drying, and is very durable in contact with the soil; dark or light brown in color; the sapwood lighter. It is used for construction, cooperage, shipbuilding, fencing, railroad ties, fuel, and occasionally for carriage stock. Large quantities have been cut in the Piedmont section for staves, and it is extensively used throughout the middle and eastern counties for posts, ties, etc.

Quercus lyrata, Walter.

(OVERCUP OAK. SWAMP POST OAK.)

A large tree, with rough flaky gray bark, and smooth gray small often pendulous branches, reaching a height of 100 and a diameter of 3 feet.

It occurs in wet soil, from Maryland southward near the coast, to western Florida, westward through Alabama, Mississippi, and Louisiana, to the valley of the Trinity river, Texas, and through Arkansas and southeastern Missouri to middle Tennessee, southern Indiana, and Illinois; reaching its best development in the valley of the Red river and adjacent portions of Arkansas and Texas. It is rare in the Atlantic states.

In North Carolina it occurs on the oak flats of the coastal plain, and in the alluvial swamps of the rivers as far inland as Anson, Orange, and Nash counties. (Fig. 20.)

The overcup oak bears acorns plentifully at intervals of 3 or 4 years, but young seedlings are infrequent. The fruit is devoured by swine, and the young plants are destroyed by browsing cattle.

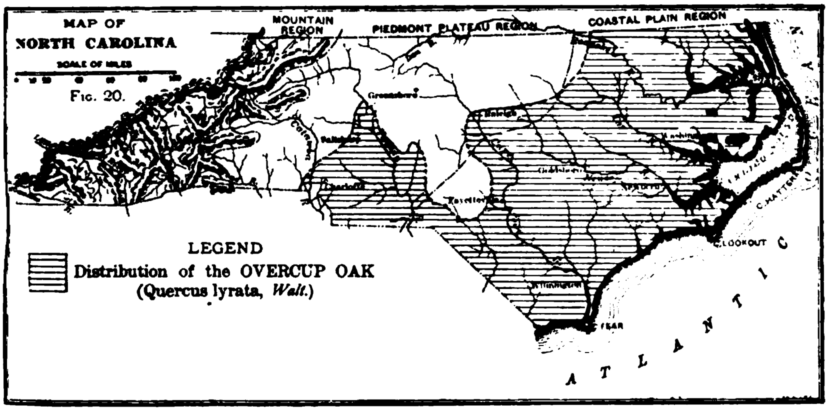


Fig. 20.

The leaves are oblong, crowded at the ends of the branchlets, and 7 to 9-lobed, the divisions acute or blunt, entire or somewhat toothed. The large subglobose acorn is nearly covered by the scaly, thin, rugged, fringed cup. The light chestnut-brown winter-buds are small and egg-shaped. The overcup oak has a tap-root and many rather deeply seated lateral roots.

The wood is heavy, hard, strong, tough, close-grained, and inclined to check, and very durable in contact with the soil; rich dark brown in color; the sapwood lighter. It is used for the same purposes as that of the white oak. Very little of this timber has ever been cut.

Quercus prinus, Linnæus.

(ROCK CHESTNUT OAK. CHESTNUT OAK. BUCK OAK.)

A large tree, with deeply furrowed dark gray bark, and a broadly oval crown, reaching a height of 100 and a diameter of 4 feet.

It occurs from southern Maine to the shores of Lake Champlain, Quinte bay, Ontario, and the valley of the Genesee river, New York, south to Delaware, and through the Appalachian mountain region to northern Alabama, extending westward to central Kentucky and Tennessee.

In North Carolina it is found on dry soil and on the tops of ridges westward from Franklin and Montgomery counties. It reaches its best development on the slopes of the lower mountains at an elevation of 2,000 to 4,000 feet, where with other oaks and the chestnut it constitutes a large part of the forest. Above 4,000 feet it grows on the driest and rockiest ridges, often forming extensive groves of pure forest. In the Piedmont plateau region a smaller form is found, which seldom reaches a diameter of one foot. (Fig. 21, p. 95.)

The rock chestnut oak bears acorns very plentifully nearly every year, or in the deep woods every second year. Young trees in all stages of growth are common in open woods on dry rocky mountains or in abandoned fields. In Lincoln and Union counties the chestnut oak forms a considerable part of the regrowth after the removal of mixed hardwoods and the short-leaf pine. Only the smaller trees sprout from the stump. Many of the large specimens growing upon dry soil are hollow at the butt as a result of frequent fires. Borers often penetrate the lower parts of the stems of small trees which occur on dry ground, but trees in damp situations are nearly always sound.

The leaves are upon short stems, usually broadest toward the extremity, and with 6 to 13 large rounded teeth on each side. The acorns are large and oval, with thick, warty cups. The large blunt winter-buds and the twigs are smooth. The numerous, branching roots penetrate deeply into the soil.

The wood is heavy, hard, strong, rather tough, close-grained, durable in contact with the soil, and inclined to check in drying; dark brown in color; the sapwood lighter. It is largely used for fencing, railroad ties, and fuel. The bark is rich in tannin.

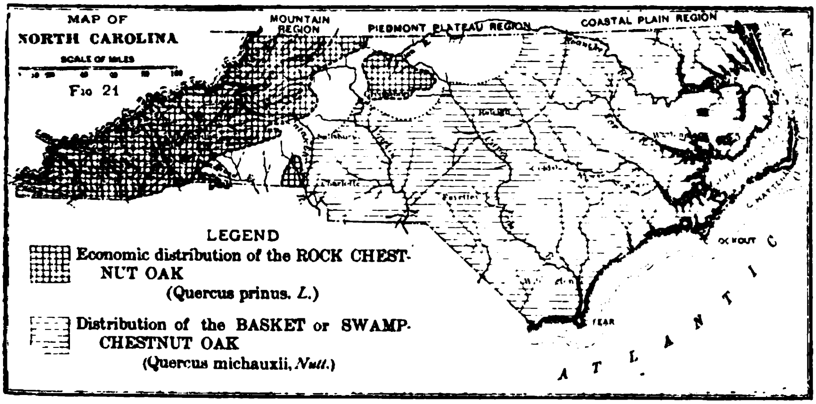
A large amount of bark is peeled in Buncombe, Burke, McDowell, and Wilkes counties to supply local tanneries, and much timber has been cut in Lincoln county for charcoal. Large quantities of chestnut oak still remain, however, in all the western counties.

Quercus michauxii, Nuttall.

(BASKET OAK. COW OAK. SWAMP WHITE OAK. SWAMP CHESTNUT OAK.)

A large tree, of great economic value, with gray rather scaly bark and stout branches, reaching a height of 120 and a diameter of 7 feet.

It occurs from Delaware, south through the lower and middle districts to northern Florida, thence through the Gulf states to the valley of the Trinity river, Texas, and through Arkansas to southeastern Missouri, to central Tennessee and Kentucky, and the valley of the lower Wabash river; reaching its best development on the rich bottom lands in southeastern Arkansas and Louisiana. It is common in the Gulf states.


MAP OF
NORTH CAROLINA
SCALE OF MILES
FIG 21
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
▦ Economic distribution of the ROCK CHESTNUT OAK (Quercus prinus. *L.*)
▤ Distribution of the BASKET or SWAMP-CHESTNUT OAK (Quercus michauxii, *Nutt.*)
A T L

In this State (fig. 21.) it is found in swamps of the coastal plain and Piedmont plateau regions, and on the bottom lands of the Cape Fear and Neuse rivers, attains a height of 100 and a diameter of 6 feet.

Abundant production of seed occurs at intervals of 2 to 3 years. Seedlings are common in wet open spots on damp hill sides in the

Piedmont plateau region. Sprouts grow readily from the stump, but seldom reach a large size.

The leaves are rather rigid, downy beneath, and with large regular, rounded teeth. The large sweet edible acorns are set in shallow cups which are roughened with acute coarse scales. The brown winter-buds are large, smooth, and pointed. There are many deep lateral roots.

The wood is heavy, hard, very strong, tough, close-grained, compact, easily split, and very durable in contact with the soil; light brown in color; the sapwood darker. It is used for agricultural implements, cooperage, wheel stock, baskets, fencing, fuel, and construction. In the eastern counties a small quantity of the timber has been cut for local uses.

Quercus virginiana, Miller.*

(LIVE OAK.)

A large evergreen tree, with dark, deeply furrowed bark and gray branches, a short body and a flat or spreading top, reaching a height of 60 and a diameter of 7 feet; in the interior of Texas often reduced to a shrub. (Plate VIII.)

It is found near the coast from Virginia to southern Florida and along the Gulf coast to Mexico, extending through western Texas and the valley of the Red river, the Apache and the Gaudalupe mountains, and into Mexico, at elevations of six to eight thousand feet, and in the island of Costa Rica; reaching its best development in the south Atlantic states.

In North Carolina it occurs near the coast on deep sandy soil with the water and willow oaks, American olive, and southern lin. North of Cape Hatteras it is a rare tree but south of that point it becomes more abundant until, at the mouth of the Cape Fear river, it forms with the palmetto a considerable part of the maritime forest of Smith's island. (Fig. 22, p. 97.)

The growth, particularly in youth, is very vigorous. Young seedlings are common near old trees. Small trees sprout readily from the stump.

The evergreen leaves are thick, leathery, oblong and obtuse,

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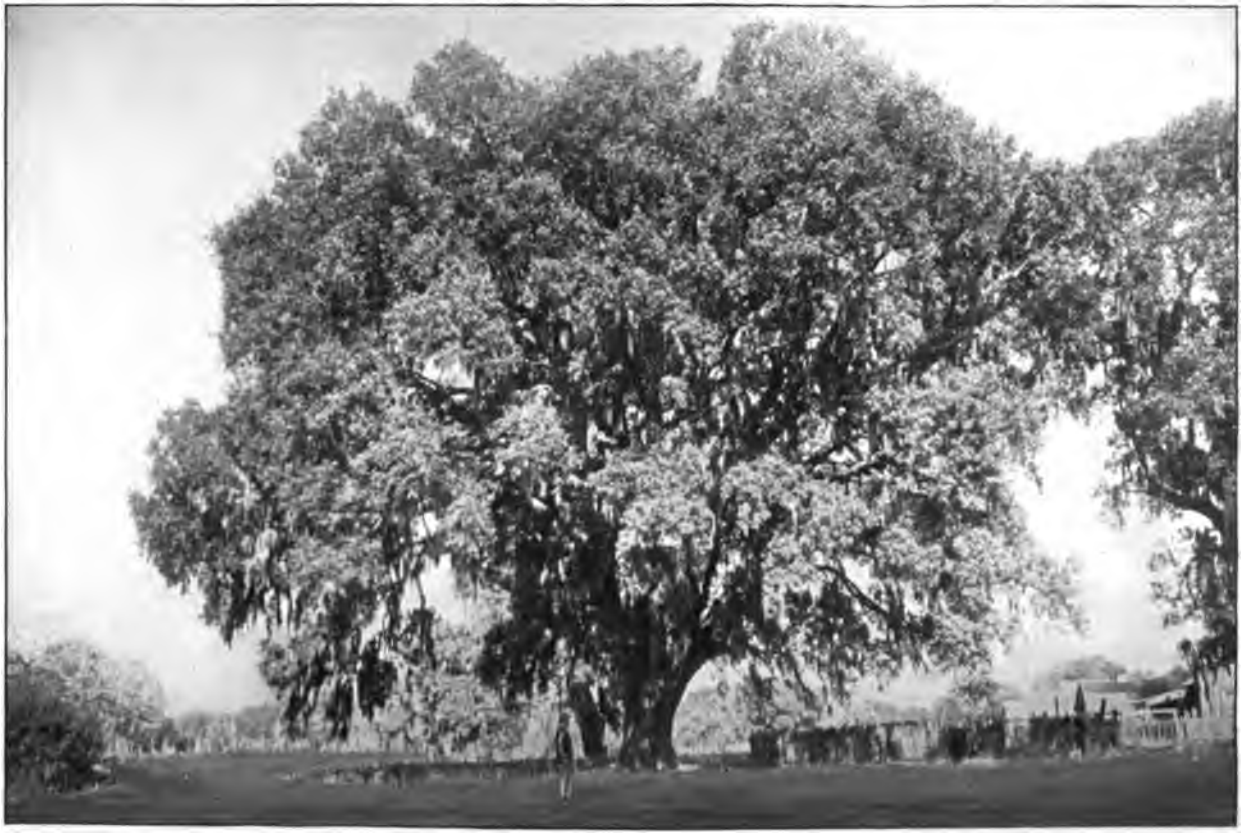
*Quercus virens, Aiton.



LIVE OAK ORTON PLANTATION

GROWN IN OPEN FIELD. LONG MOSS (TILLANDSIA) HANGING FROM THE LIMBS

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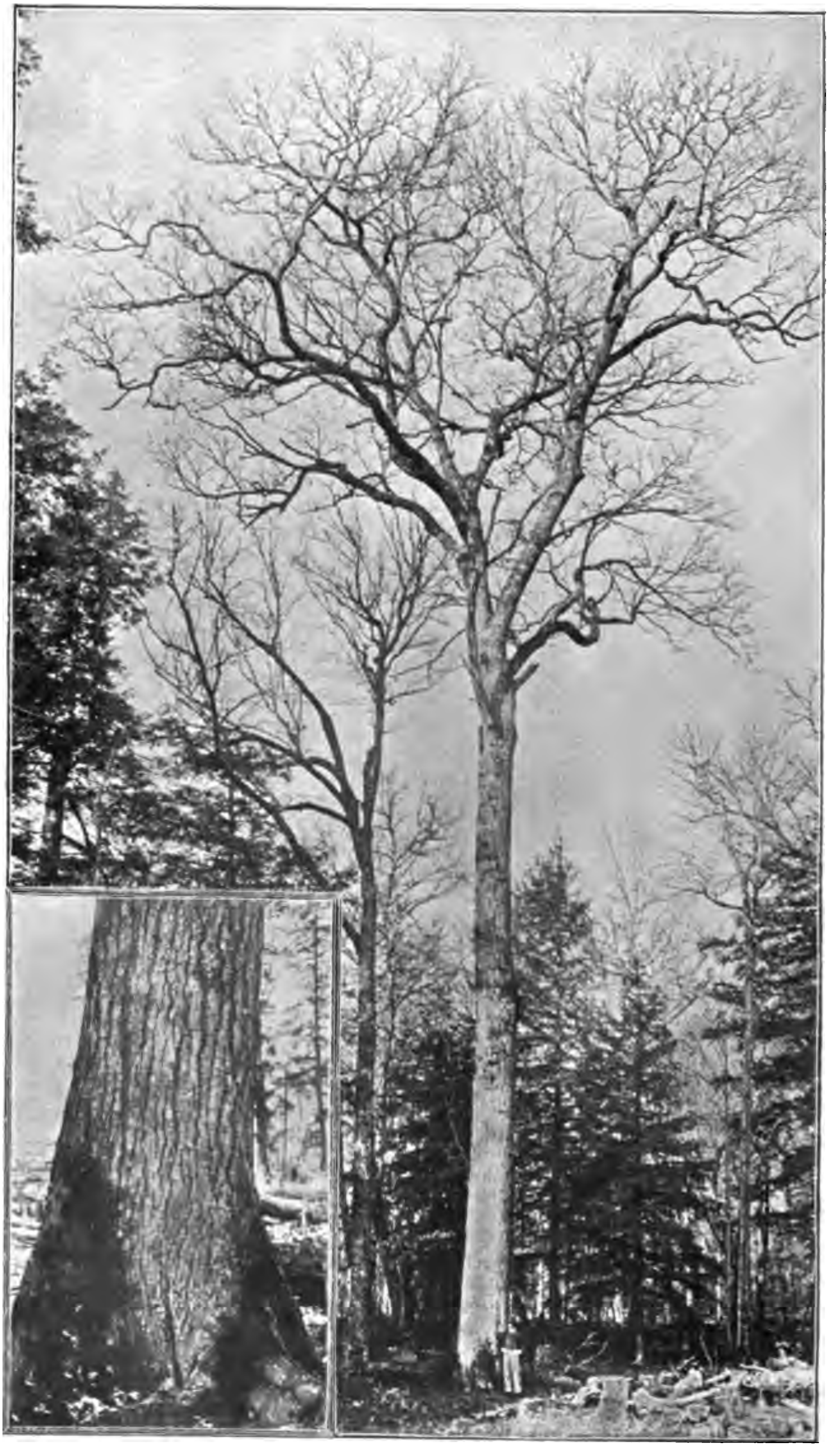

RED OAK

smooth above, and hairy beneath. The fruit, which is borne upon a long stem, is an oblong, dark brown, or black acorn set in a top-shaped, downy cup. The roots are spreading and rather deeply seated, and can bear sea water, at least if covered only during high tide.

The wood is very heavy, hard, strong, tough, close grained, compact; it takes a beautiful polish, but is difficult to work; light brown or yellow in color; the sapwood nearly white. It is used for shipbuilding, and the bark is occasionally employed for tanning. It is not abundant enough in North Carolina to be of commercial importance.

Quercus rubra, Linnæus.

(RED OAK.)

A large tree, with dark brown furrowed bark, nearly black on large trunks, and rather smooth branches which form a large oval or round head, reaching a height of 150 and a diameter of 7 feet. (Plate IX.)

It occurs from Nova Scotia, southern New Brunswick, and eastern Minnesota, western Iowa, eastern Kansas and Indian Territory south to northern Florida, southern Alabama and Mississippi, and western Texas, reaching its best development north of the Ohio river. A common tree.

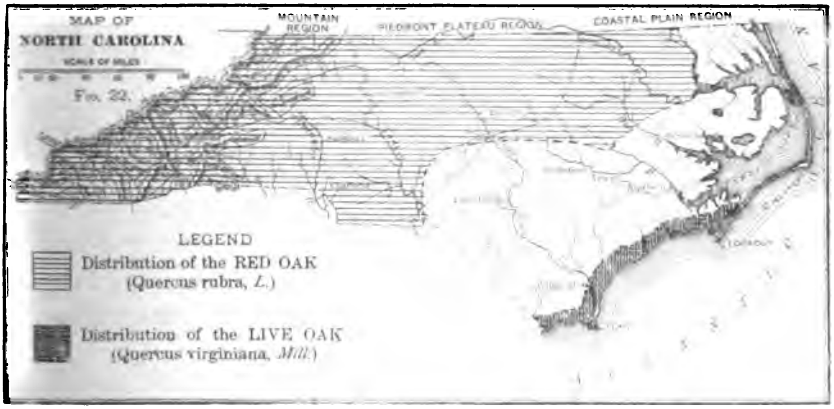
MAP OF
NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
▤ Distribution of the RED OAK (Quercus rubra, *L.*)
■ Distribution of the LIVE OAK (Quercus virginiana, *Mill.*)

Fig. 22.

In the coastal plain region of North Carolina it is rare; somewhat more common in the Piedmont plateau on shady hillsides and finely ridged bark, and smooth gray branches which form an oval top, reaching a height of 175 and a diameter of 4 feet.

It occurs from Maine to Ontario, Minnesota, and Nebraska, and south to North Carolina; reaching its best development in the lower Ohio basin. It is usually confounded with the black oak.

In North Carolina, where it attains a height of 80 and a diameter of 3½ feet, it occurs sparingly in the coastal plain on sandy loam, but is more common in the Piedmont plateau on gravelly loam growing with the post oak, white oak, and short-leaf pine. In the mountains, at an elevation of 2,500 to 3,500 feet, it is one of the commonest trees. (Fig. 24.)

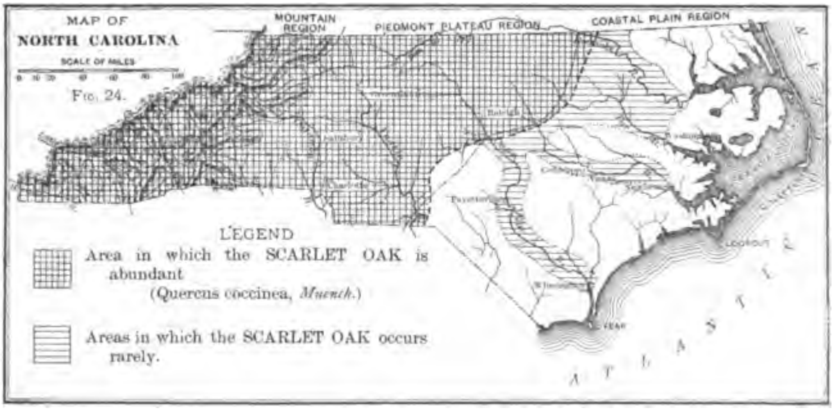

FIG. 24.

The scarlet oak bears acorns plentifully every 2 or 3 years, and young plants are common through the woods in many of the western counties. Only young trees sprout readily from the stump. Trees over 3 feet in diameter are usually hollow or red-hearted, dry rot causing the defect.

The thin smooth leaves are on long slender stems and deeply cut into long lobes by broad round notches. They turn to a brilliant scarlet in the autumn. The small oval acorns are strongly pointed and half-imbedded in a deep coarsely-scaled cup. The slender, slightly angled winter-buds are pointed, and, like the slender twigs, smooth and reddish. The root system of older trees is distinctly lateral, many of the roots being superficial, or frequently exposed.

The wood is heavy, hard, strong, and close-grained ; the heartwood light brown or red ; the sapwood rather darker. The lumber, if used at all, is confounded with that of the red oak. The bark is sometimes used in tanning, but is inferior to that of the black oak. It is rarely used in this State except for coarse staves and shakes, and for fuel.

Quercus velutina, Lamarck.*

(BLACK OAK.)

A large tree, with rough or deeply furrowed nearly black bark, grayish branches, a long clear trunk, and an oval crown, reaching a height of 160 and a diameter of 6 feet.

It is very common on dry or gravelly uplands from Maine to Minnesota, eastern Nebraska, Kansas, and Indian Territory, and south to western Florida, and eastern Texas. It reaches its best development in the valley of the lower Ohio river.

In North Carolina (fig. 25), where it attains an average height of 80 to 90 and an average diameter of 4 to 5 feet, it is most abundant in the upper part, and occurs very sparingly, if at all, in the lower.

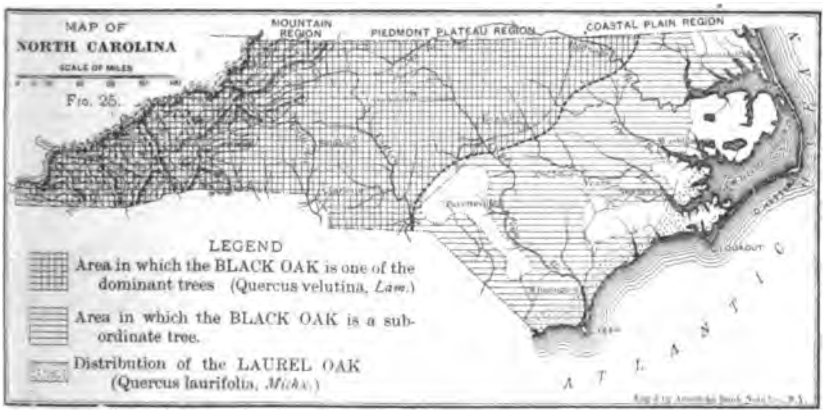

Fig. 25.

MAP OF
NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
Area in which the BLACK OAK is one of the dominant trees (Quercus velutina, *Lam.*)
Area in which the BLACK OAK is a subordinate tree.
Distribution of the LAUREL OAK (Quercus laurifolia, *Michx.*)
LOOKOUT
A T L A N T I C

It bears fruit abundantly at intervals of 2 or 3 years, and seedlings are common under the light shade of the parent tree. Black oak forms a large part of the second growth mixed hardwood forests in the middle and the lower part of the Piedmont plateau. Large trees are often hollow or red-hearted.

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*Quercus tinctoria, Bartram.

The forest tent caterpillar, Clisiocampa disstria, Huebner, is often destructive to the foliage, and much injury is also caused, especially to young trees, by the oak pruner, Elaphidion villosum, Fabricius.

The leaves are inversely egg-shaped, thicker and less deeply cut than those of the scarlet oak, and usually darker in color and less polished. The small acorn, nearly half enclosed in a thick scaly cup, contains a yellowish and very bitter kernel.

The buds are thick, pyramidal, and downy. There are many deeply penetrating lateral as well as superficial running roots.

The wood is heavy, hard, strong, not tough, coarse-grained, liable to check in drying; bright brown tinged with red in color; the sapwood much lighter. It is used for cooperage, construction, etc. The bark is largely used for tanning. Quercitron, a valuable yellow dye, is derived from the inner bark, which has astringent medicinal properties.

It has been cut extensively throughout the Piedmont plateau for building material and cooperage, and locally the bark has been employed to a considerable extent in tanning.

Quercus catesbæi, Michaux.

(FORK-LEAVED BLACK-JACK OAK. SAND BLACK-JACK OAK. SCRUB OAK. TURKEY OAK.)

A small tree, with oval crown, numerous irregular drooping branches, and deeply furrowed black bark, reaching a height of about 50 and a diameter of 2 feet.

It occurs upon barren sandy hills and ridges from Gates county, N. C., to central Florida, and along the coast to eastern Louisiana.

In this State (fig. 23, p. 99) it is common south of the Neuse river in the pine barrens, where it has a height of about 20 feet and a diameter of 8 inches.

Fork-leaved black-jack oak, generally bears fruit annually, and seedlings are very abundant on dry sandy soil. Its growth is rapid, but in North Carolina the tree seldom lives longer than 40 years. It grows frequently with the long-leaf pine, and often replaces it after lumbering.

The rather leathery, broadly oval leaves are deeply lobed. The large ovoid acorn is half enclosed in a short-stalked, thick, top-shaped cup. The winter buds are large, conical and covered with brownish down. The root system consists of deep lateral roots.

The wood is heavy, hard, strong, close-grained, compact, and light brown in color; the sapwood somewhat lighter. It is largely used for fuel. The ash is rich in alkali and the bark in tannin.

Quercus digitata, Sudworth.*

(SPANISH OAK. RED OAK.)

A tree, with a large spreading top, nearly black rough bark, and smooth dark gray branches, reaching a height of 100 and a diameter of 6 feet.

It occurs from southern New Jersey south to middle Florida, through the Gulf states to the Brazos river, Texas, and through Arkansas and southeastern Missouri to central Tennessee and Kentucky, southern Illinois and Indiana; reaching its best development in the South Atlantic and Gulf states.

In North Carolina where it attains an average height of 70 to 80 and a diameter of 3 to 4 feet, growing on dry heavy soils, it is very common throughout, (fig. 26,) although rather less so toward the mountains.

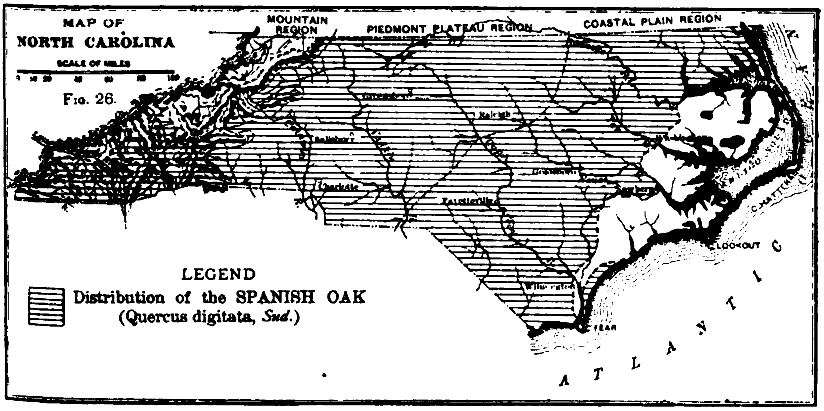
FIG. 26.

Acorns are borne in abundance every 3 or 4 years, and young seedlings are plentiful in rather dry open woods. On the dry, rocky uplands of the counties in the middle part of the State, a considerable part of the second growth is composed of this species. Trees over 3 feet in diameter are generally not sound at the heart. Coppice shoots are very abundant around the stumps of smaller trees. This tree is sensitive to late frosts.

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* Quercus cuneata, Wangenheim and Q. falcata Michaux.

The leaves are divided into 3 to 5 prolonged, mostly narrow, bristle-tipped lobes, and are downy on the lower surface. The short-stemmed fruit consists of a small globose acorn half enclosed in a somewhat top-shaped cup. The light brown winter-buds are covered with a light reddish down. The Spanish oak has, in addition to many deeply penetrating lateral roots, numerous long superficial running roots.

The wood is heavy, very hard, strong, not durable, coarse-grained, and checks badly in drying; light red in color; the sapwood lighter. It is used for cooperage, construction, and very largely for fuel. The bark is rich in tannin. A large amount of Spanish oak timber is still standing in the Piedmont plateau region, where it is one of the most common trees.

Quercus marilandica, Muenchhausen.*

(BLACK-JACK OAK.)

A small tree, with rough black bark, and drooping irregular branches, reaching a height of 60 and a diameter of 2 feet.

It occurs from Long Island, New York, to Wisconsin, southern Minnesota, eastern Nebraska, Kansas, and Indian Territory, and south to Florida and Texas; reaching its best development in southern Arkansas, and eastern Texas.

In North Carolina, where it has an average height of not more than 25 feet, it is found upon barren clay or loam soils, gravelly for the most part. It occurs in all sections, but is rare in the more elevated mountain counties.

It bears fruit plentifully about every other year; and seedlings are abundant near the parent trees and in second growth woods.

The large thick wedge-shaped leaves are smooth on the upper and covered with a rusty pubescence on the lower surface. The

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*Quercus nigra, Linnæus.

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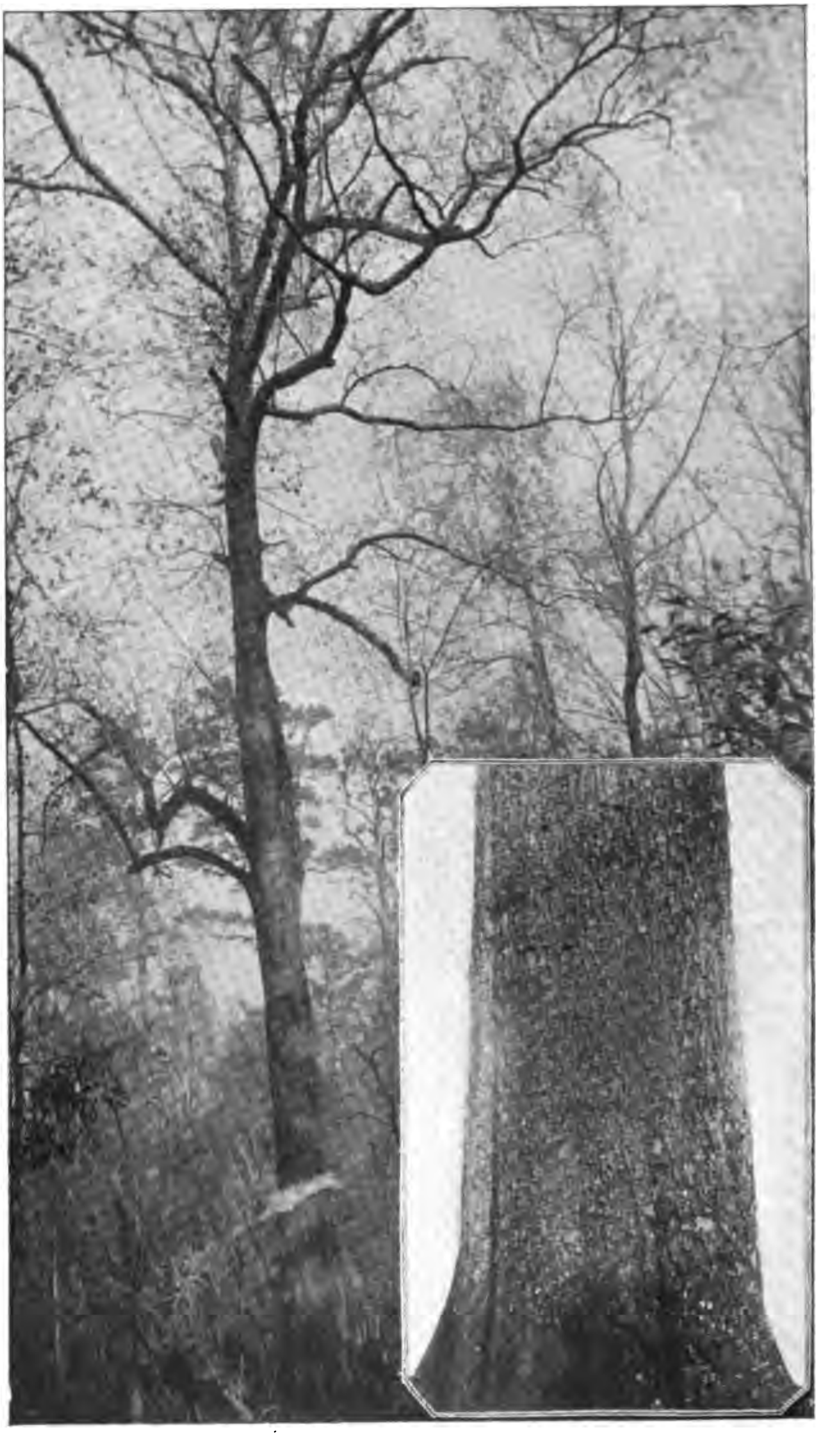


WATER OAK

small globular acorn is half enclosed in a top-shaped, coarse-scaled cup. The conical, bright brown winter-buds are covered, like the angular twigs, with a light gray down. The buds are frequently injured by late frosts. The black-jack oak has a lateral root system.

The wood is heavy, hard, and strong, and checks badly in drying; dark red-brown in color; the sapwood much lighter. It is little used except for fuel.

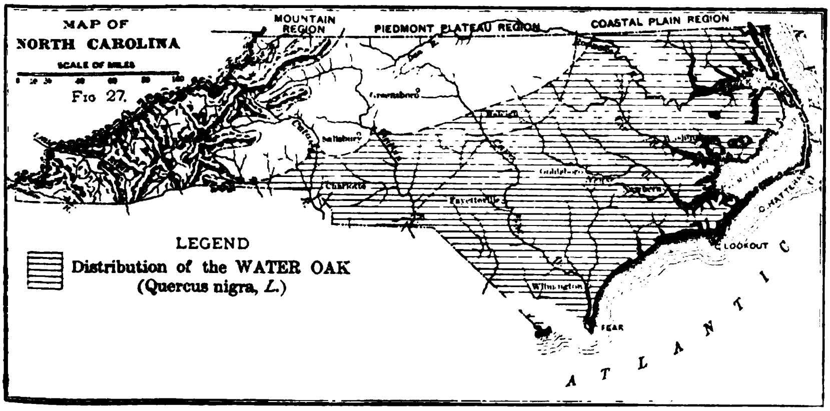
Quercus nigra. Linnæus.*

(WATER OAK.)

A small tree, with a large spreading top, dark rough bark at the base of the stem and smoother gray bark above, reaching a height of 80 and a diameter of 4 feet. (Plate X.)

It occurs from Delaware through the coast and middle districts to Florida and Texas, and westward to Missouri and Indian Territory; reaching its best development in the maritime pine belt of the eastern Gulf states. A common tree.

In this State, where it reaches an average height of 40 to 50 feet and an average diameter of 12 to 20 inches, it is abundant on moist soil, usually bordering swamps and streams, in the coastal plain region and some parts of the Piedmont plateau region. (Fig. 27.)



It is one of the commonest trees on the oak flats about the swamps of the coastal plain.

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*Quercus aquatica, Walter.

The larger, crown-forming limbs are often broken, and the stem is very frequently hollow or red-hearted. The trunk is apt to be covered with adventitious shoots. Even large trees send up numerous sprouts from the stump. The growth is generally rapid.

The leaves are generally deciduous, although, on the coast, many remain green during the winter, especially on vigorous shoots. They are thick, smooth, narrowed at the base, and rounded, or 3-lobed and bristle-tipped at the extremity. The small globular-ovoid acorn is set in a very shallow cup. The winter-buds are small and conical, upon slender flexible polished brown twigs. The lateral superficial roots are large and well developed.

The wood is heavy, hard, strong, coarse-grained, and compact; rather light brown in color; the sapwood lighter. It is used only as fuel.

Quercus laurifolia, Michaux.

(LAUREL OAK. WATER OAK. WILLOW OAK. PIN OAK. TURKEY OAK.)

A tree, with dark brown minutely roughened bark, and smoother and lighter branches which form an oval crown, reaching a height of 100 and a diameter of 4 feet.

It occurs from North Carolina southward near the coast to Mosquito Inlet and Cape Romano, Florida, and along the Gulf coast to Mobile bay; reaching its best development on the Florida coast. A very common tree.

In North Carolina, where it grows to a height of 60 to 70 and a diameter of 3 feet, it is found on sandy loam in the coastal plain region on oak flats bordering swamps, and in the Piedmont plateau usually on damp soils along streams. (Fig. 25, p. 101.)

It bears fruit plentifully once in 3 or 4 years, and in the coastal plain, in moist open woods, seedlings are abundant.

The leaves are thick, smooth, and rounded at each end. The small globose or slightly oval dark brown acorns are set in somewhat pointed very short stemmed cups. The twigs are smooth, slender, and dark brown, the buds pointed and lighter colored. The numerous lateral roots generally do not penetrate very deeply into the soil.

The wood is heavy, very strong, hard, coarse-grained, and inclined to check in drying; dark brown in color; the sapwood lighter. It is sometimes, although rarely, used for clapboards and coarse staves.

Quercus brevifolia. Sargent.*

(UPLAND WILLOW OAK. TURKEY OAK. BLUE JACK.)

A small tree, with large oval crown, rough dark gray bark, and slender drooping branches, reaching a height of 50 feet and a diameter of 18 to 20 inches.

It occurs on sandy barrens and dry ridges from North Carolina near the coast to Cape Malabar and Pease creek, Florida, and westward along the Gulf coast to eastern Texas.

In this State, where it has an average height of 30 feet and a diameter of 10 inches, it is found in the pine barrens of the coastal plain region. Immediately along the coast it sometimes reaches a larger size.

It bears fruit abundantly and at frequent intervals, and seedlings and young trees are common on the dry pine barrens.

The oblong entire leaves are bristle-tipped and covered with a white down on the lower surface. About one-third of the small globose hoary acorn is covered by a stemless shallow cup. The winter-buds are small and oval.

The wood is heavy, hard, strong, close-grained, and compact; light brown in color; the sapwood darker. It is used only for fuel. The bark yields a fine yellow dye.

Quercus imbricaria, Michaux.

(SHINGLE OAK.)

A slender tree, with dark gray, rough or rather smooth bark, and smooth, light gray branches which form a large spreading top, reaching a height of 100 and a diameter of 4 feet.

It occurs from Pennsylvania westward to western Missouri and northeastern Kansas, and south to northern Georgia and Alabama,

*Quercus cinerea, Michaux.

middle Tennessee, and northern Arkansas; reaching its best development in the basin of the Ohio river.

In this State, where it attains an average height of 40 to 50 feet and an average diameter of 12 to 15 inches, it is confined to the mountains and western part of the Piedmont plateau, where it is usually found along streams on alluvial loams. (Fig. 28.)

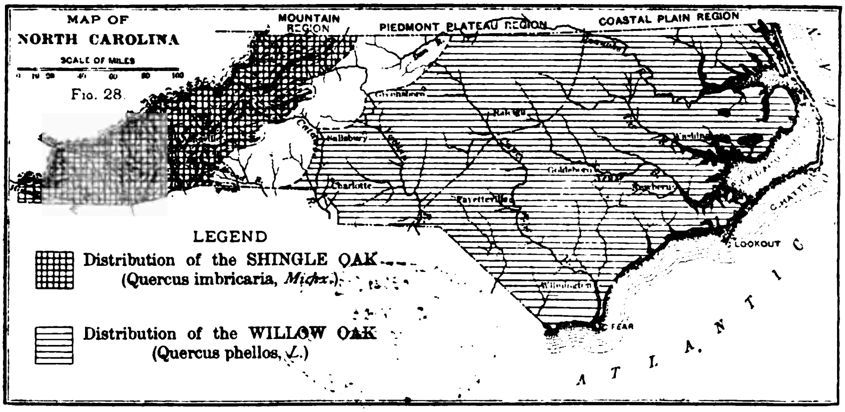

Fig. 28.

Seed years are frequent and young seedlings are common, near the parent tree, on moist valley lands in the mountains.

The oblong lance-shaped leaves are entire, pale downy below, and tipped with an abrupt sharp point. The acorn is nearly globular and about one-third to one-half enclosed by a cup which is covered with broad whitish closely appressed scales. The brown winter-buds are acute and small-scaled.

The wood is heavy, hard, rather coarse-grained, and checks badly in drying; light brown in color; the sapwood much lighter. It is occasionally used for clapboards and shingles, and in construction.

Quercus phellos, Linnæus.

(WILLOW OAK.)

A tree, with large spreading crown, rough dark brown bark, and smooth branches, reaching a height of 80 and a diameter of 4 feet.

It occurs from Staten Island, New York, south near the coast to

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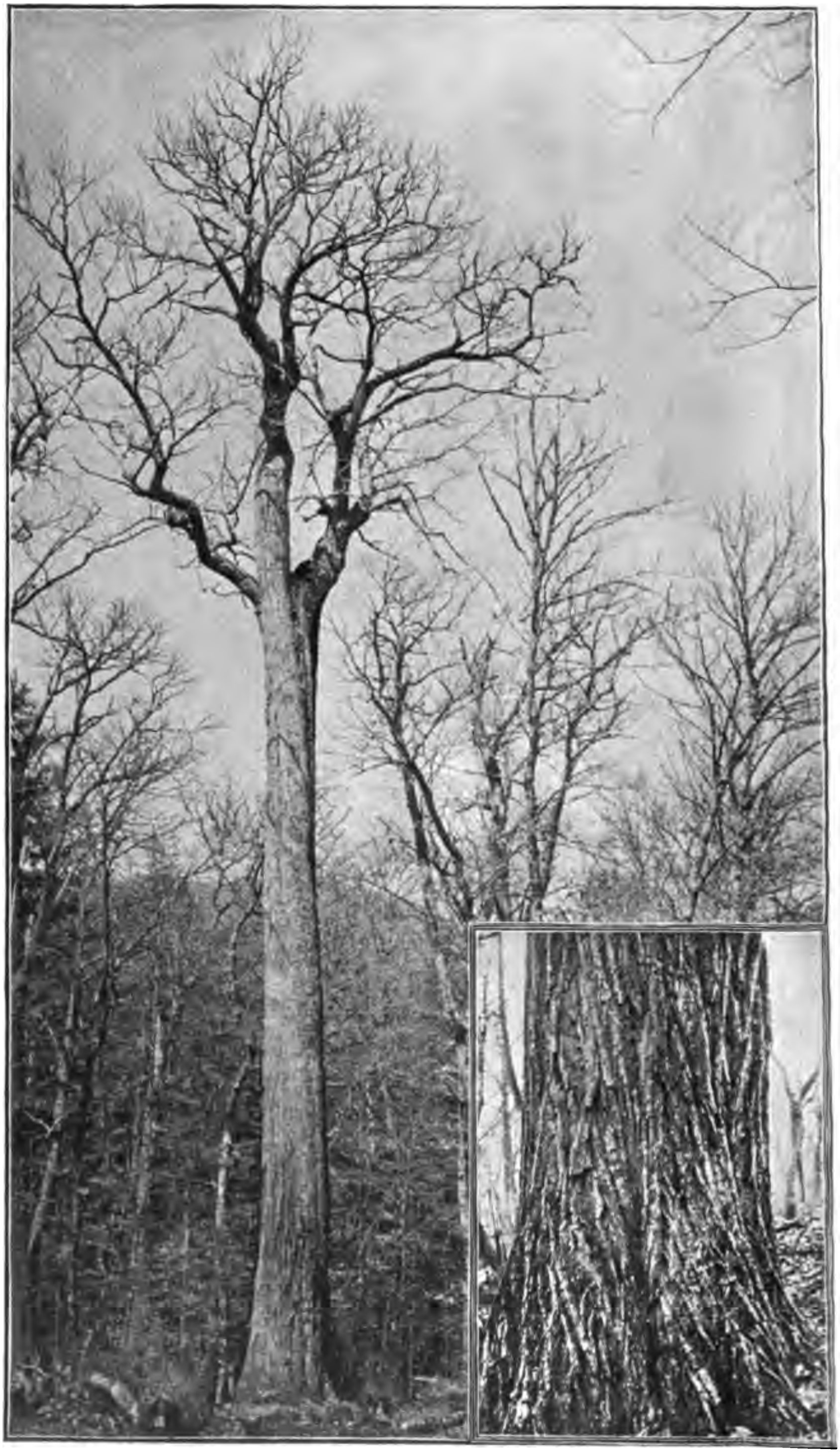


CHESTNUT

northeastern Florida, through the Gulf states to eastern Texas, and through Arkansas to southeastern Missouri, Tennessee, and southern Kentucky.

In this State, where it reaches an average height of 50 to 60 and an average diameter of 2 feet, it occurs in large numbers in the coastal plain region and, scatteringly, in the Piedmont plateau region, in moist situations. (Fig. 28, p. 108).

The willow oak forms a considerable portion of the second-growth hardwood forests on the moist sandy loams of the coastal plain region and young trees are common along the streams of the Piedmont plateau. Young trees sprout vigorously from the stump.

The leaves are narrow, lance-shaped, pointed at each end, thick, entire or nearly so, and downy when young. The acorns are small, globose, and set in a shallow flattened cup. The buds are small, pointed, smooth, and light brown ; the twigs slender. The willow oak has numerous spreading lateral roots.

The wood is heavy, strong, not hard, rather close-grained, compact ; light brown in color tinged with red ; the sapwood a lighter red. It it somewhat used for the felloes of wheels, clapboards, and in construction.

Castanea dentata, Borkhausen.

(CHESTNUT.)

A very common large and valuable tree, with deeply furrowed dark gray bark, and smooth light gray branches which form a large spreading crown, reaching a height of 120 and a diameter of 13 feet. (Plate XI.)

It occurs from southern Maine, southern Ontario, and southern Michigan, southward to Delaware and middle Tennessee, and along the Appalachian mountains to northern Alabama, reaching its best development on the western slopes of the southern Alleghanies.

In North Carolina, where it is confined to the mountain region (fig. 29), it reaches an average height of 50 to 70 and an average diameter of 5 feet, but in favorable locations it sometimes attains the largest dimensions given above.

Abundant production of seed occurs about every other year. Young plants are plentiful in moderately open woods and in old fields. The young trees are decidedly light-demanding and die quickly in deep shade. Specimens over 5 feet in diameter are generally unsound. After lumbering a growth of the same species, together with oaks, (generally the white, scarlet and black oak) springs up. The chestnut enters largely into the composition of most second growth hardwood forests in the extreme western counties. It sprouts very freely from the stump and the shoots often grow to be large trees. The stumps retain their power of sprouting for many years. The trunk is sometimes attacked by the chestnut borer, Arliopalus fulminans, Fabricius, and the nuts by the chestnut weevil, Balaninus caryatrypes, Boheman.

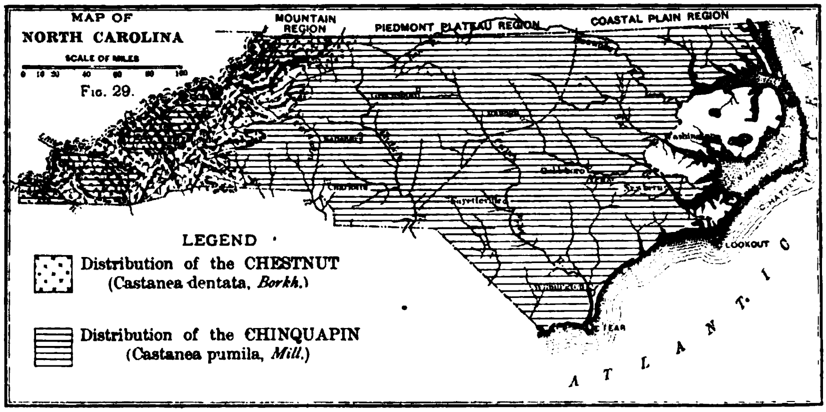


Fig. 29.

The thin oblong leaves are straight-veined and serrate with coarse sharp teeth. The yellowish-green sterile flowers are in large spreading bunches of catkins, appearing in the middle of the summer; the fertile flowers are inconspicuous. The fruit consists of 2 or 3 flattened dark brown shining edible nuts enclosed in a light brown prickly bur. The winter-buds are small and ovate. A tap-root is early developed. Later, strong deeply seated lateral roots are formed.

The wood is light, soft, not strong, coarse-grained, easily split, very durable in contact with the soil, and liable to check and warp in drying; brown in color; the sapwood lighter. It is used for cabinet-making, interior finish, railway ties, fencing, and posts, and is well adapted for charcoal. An extract from the leaves is used medicinally.

The chestnut is very common in the mountain counties of North Carolina at an elevation of 2,500 to 4,500 feet, and is sawed extensively for local uses.

Fagus ferruginea, Aiton.

(BEECH.)

A tree, with round or oval crown, smooth light gray bark, and delicate branchlets, reaching a height of 110 and a diameter of 4 feet.

It occurs from Nova Scotia and northern Wisconsin, south to western Florida and eastern Texas; reaching its best development on the bluff formations of the lower Mississippi basin.

In this State, where it attains an average height of 50 to 80 and an average diameter of 2 to 3 feet, it is found sparingly and of small size in the coastal plain region, more commonly and of larger growth in the Piedmont plateau, and most abundantly and of greatest size in the mountain region.

The beech bears seed plentifully every 4 or 5 years, or along streams or in sheltered hollows more frequently. Young seedlings are common in damp shady woods, especially above 3,000 feet elevation. Towards the summits of many high mountains it forms, with birch and sugar maple, nearly the entire growth. The young trees are capable of enduring deep shade.

The leaves are thin, smooth, and straight-veined, each vein ending in a large tooth. The sterile flowers occur in small heads upon drooping silky stems, and the fertile flowers are often in pairs on the summit of short stalks. The fruit consists of a prickly bur, enclosing two triangular sharp-ridged edible nuts. The brown winter-buds are long, slender, and pointed; the twigs small and smooth. The root system consists of long superficial roots which are frequently exposed.

The wood is very hard, strong, tough, very close-grained, not durable in contact with the soil, and inclined to check in drying;

dark or lighter red in color; the sapwood nearly white. It takes a beautiful polish, and is used for chairs, shoe-lasts, plane-stocks, handles, and for fuel. The bark is sometimes used for tanning, and a valuable oil is derived from the nuts. The wood is little used in North Carolina except for fuel.

Ostrya virginica, Willdenow.

(HOP HORNBEAM. IRONWOOD.)

A small tree, with smooth dark brown branches, brownish finely furrowed bark, and an oval head, reaching a height of 50 and a diameter of 2 feet.

It occurs from the Bay of Chaleur to northern Minnesota, south to eastern Texas, and along the Appalachian mountains and Piedmont region to western Florida; reaching its best development in southern Arkansas.

In North Carolina, where its average height is 20 to 30 feet, it occurs only in the Piedmont plateau and mountain regions. In rich spots near the summits of some of the high mountains, at an elevation of 4,500 to 5,200 feet, it forms small patches of almost pure forest or grows in mixture with the sugar maple and service tree.

The hop hornbeam bears seed at frequent intervals. Small trees sprout freely from the stump. Numerous adventitious branches grow from the trunks of older trees. It is a slow growing tree and can endure deep shade even in youth. Trees over 12 inches in diameter are very often hollow.

The thin leaves are oblong-ovate or elliptical, finely pointed, sharply toothed, smooth above and somewhat hairy beneath. The male flowers occur in drooping cylindrical catkins, the female in short and slender ones. The fruit is hop-like and is made up of from 12 to 20 seed vessels each containing one hard pointed nutlet. The prominent winter-buds are dark brown and cone-shaped. The hop hornbeam has a tap-root and deeply penetrating lateral roots.

The wood is heavy, very strong, hard, tough, very close-grained, compact, light brown in color, or often nearly white, like the sapwood. It is used for posts, levers, mill cogs, wedges, mallets, and the handles of tools.

Carpinus caroliniana, Walter.

(HORNBEAM. IRON WOOD. BLUE BEECH. WATER BEECH.)

A small tree, with a short smooth dark bluish-gray or slate-colored trunk, marked by irregular longitudinal ridges, smooth gray branches, and a round or flat spreading crown, reaching a height of 50 and a diameter of 3 feet.

It occurs from Nova Scotia to northern Minnesota, southward to central Florida, and through Iowa, Kansas, and Indian Territory to eastern Texas; reaching its best development on the western slopes of the southern Appalachian mountains, and in southern Arkansas, and in eastern Texas.

In North Carolina, where it grows to a height of 25 feet and a diameter of 14 inches, it is found along water-courses throughout the State.

It bears seed, at least in the Piedmont plateau, very frequently, and young growth is common along streams where the trees stand thinly. The best growth takes place under moderate cover, though the tree adapts itself to a wide range of light and shade.

The leaves are oblong or elliptical, rounded at the base, sharply toothed, and slightly hairy on the veins beneath. The male flowers are in drooping cylindrical catkins. The fertile spikes are terminal, long-stemmed, and 6 to 12 flowered. The angular nuts are solitary and at the base of a 3-lobed leaf-like scale. The winter-buds are small and acute; the twigs slender. The roots are superficial.

The wood is heavy, very strong, close-grained, and inclined to check in drying; light brown in color; the thick sapwood nearly white. It is used for levers, the handles of tools, etc.

Betula lutea, F. A. Michaux.

(YELLOW BIRCH. BITTER BIRCH.)

A tree, with spreading branches, and silvery yellow bark which scales off in thin sheets, reaching a height of 95 and a diameter of 4 feet.

It is common from Newfoundland to the western shores of Lake Superior and Rainy Lake, south through the northern states to Delaware, and southern Minnesota, and along the Appalachian mountains to the high peaks of North Carolina and Tennessee; reaching its best development in southern Canada and the northeastern United States.

In this State, where it attains a height of 80 to 90 and a diameter of 2 to 3 feet it is confined to the high mountains, where, in damp woods, it is not uncommon. (Fig. 30, p. 115.)

Seed is produced abundantly every 2 or 3 years, and young trees are common in damp shady woods at high elevations. It grows rapidly when the light conditions are favorable. Specimens over three feet in diameter are usually hollow.

The leaves are elliptical or ovate, coarsely toothed, and hairy on the midrib beneath. The male catkins are cylindrical and pendulous; the female short and nearly erect, which, when mature, form an egg-shaped cone, 1¼ inches long, made up of stiff tough 3-lobed scales and containing winged seeds. The flowers appear in early spring before the leaves. The prominent winter-buds are smooth and conical. The undeveloped male catkins are formed in the fall and are conspicuous during the winter. The yellow birch has a tap-root, which usually forks and takes a lateral direction, and several strong lateral roots.

The wood is heavy, very strong, hard, very close-grained, compact; light brown in color; the heavier sapwood nearly white. It takes a beautiful polish, and is used for furniture, veneering, button and tassel-moulds, spools, pill and match boxes, the hubs of wheels, flooring, and fuel.

Betula nigra, Linnæus.

(RIVER BIRCH. RED BIRCH. BLACK BIRCH.)

A tree, with a short trunk, a large, spreading top, reddish-brown furrowed bark on the stem, and on the branches reddish-white bark which separates in thin papery layers, reaching a height of 80 and a diameter of 3 feet.

It occurs in moist situations from Massachusetts southward through the coast and middle districts to western Florida, and westward to western Iowa and eastern Texas; reaching its best development in the south Atlantic states and the basin of the lower Mississippi river.

In this State, where it reaches an average height of 40 to 60 and an average diameter of 1 to 2 feet, it is found along streams and on the borders of swamps from the coast to the mountains. (Fig. 30.)

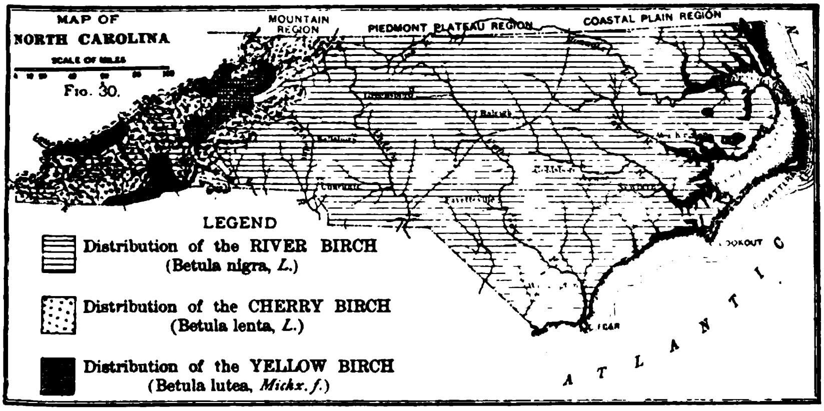


Fig. 30.

MAP OF
NORTH CAROLINA
SCALE OF MILES
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
Raleigh
LEGEND
▤ Distribution of the RIVER BIRCH (Betula nigra, L.)
⁙ Distribution of the CHERRY BIRCH (Betula lenta, L.)
■ Distribution of the YELLOW BIRCH (Betula lutea, Michx. f.)
A T L A N T I C

It bears seed at frequent intervals, and young growth is common on alluvial soil near the edges of fields and along streams. Young trees when cut send up numerous sprouts.

The leaves are acute at each end, doubly-toothed, bright green above, and glaucous beneath when young. The fruit is an oblong spike (with woolly, 3-lobed bracts), containing the small rather broadly-winged seeds. The river birch matures its seed early in summer. The winter-buds are oval and dark brown; the twigs brown, and downy when young. The root system consists of deeply penetrating lateral and running roots.

The wood is light, rather hard, strong, close-grained and compact; brown in color; the sapwood much lighter. It is used for furniture, woodenware, wooden shoes, ox yokes, etc., and cask hoops of inferior quality are made from the branches.

Betula lenta, Linnæus.

(CHERRY BIRCH. BLACK BIRCH.)

A tree, with reddish-brown rough bark on old trees, smooth dark bark which resembles that of the cherry on the branches and on young trees, and a large oval crown, reaching a height of 80 and a diameter of 5 feet. (Plate XII.)

It occurs from Newfoundland and the valley of the Saguenay river westward through Ontario to the islands of Lake Huron, southward to northern Delaware and southern Indiana, and along the Alleghany mountains to western Florida, and westward to middle Kentucky, and Tennessee.

In North Carolina, where it reaches an average height of 60 to 80 and an average diameter of 2 to 2½ feet, it is confined to the mountains. (Fig. 30, p. 115.)

It produces seed once in 3 or 4 years. Young seedlings, which are common in damp cool woods, are short lived if very heavily shaded. Old specimens, over 2 feet in diameter, are often unsound. Young trees sprout from the stump.

The ovate or oblong-ovate leaves are finely pointed, heart-shaped at the base, and sharply and irregularly toothed. The fruit is cylindrical or elliptical, with rounded ends, 1 to 1¼ inches long, and made up of small closely set scales. The buds are conical and pointed. The cherry birch has a superficial root system, although in young growth there is a prominent tap-root.

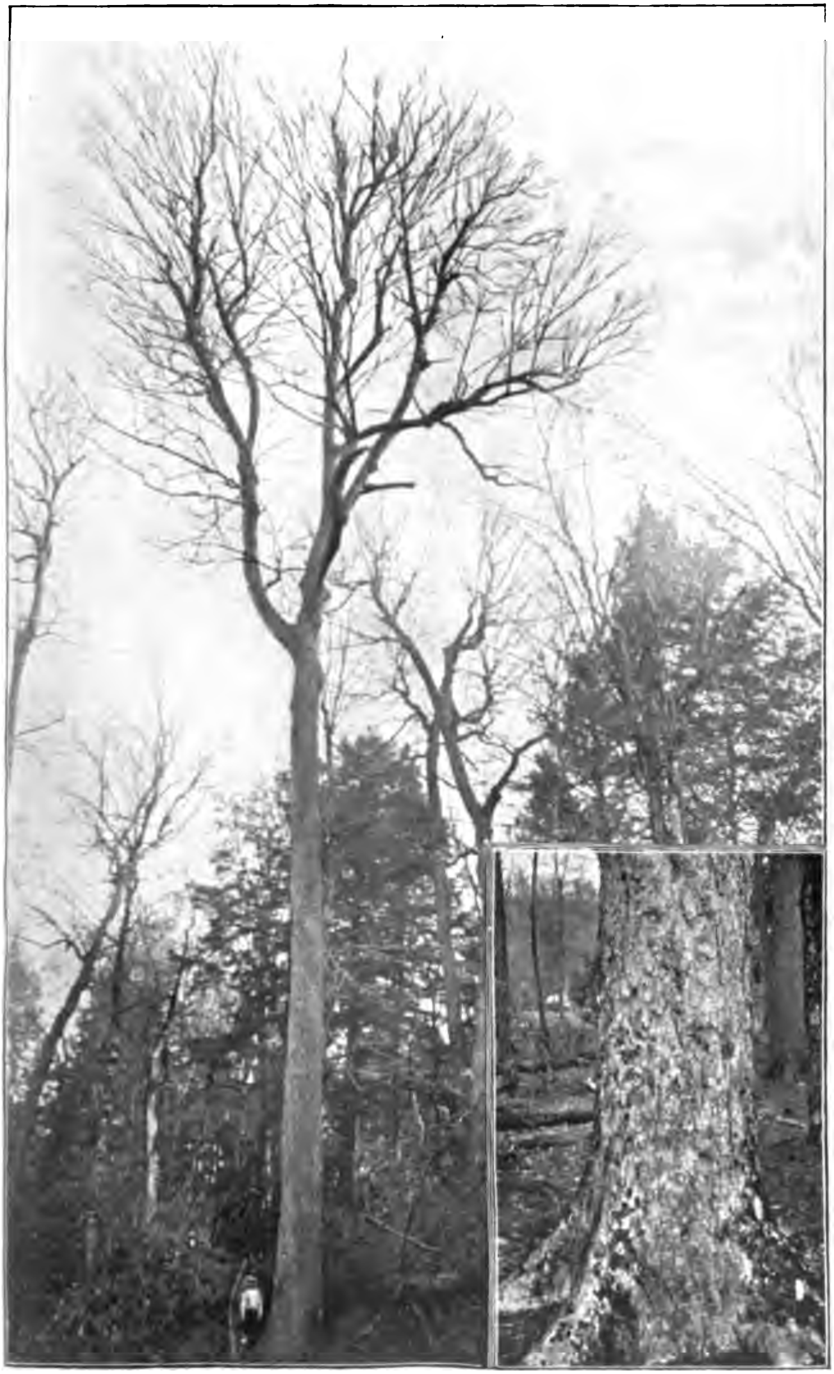
The wood is heavy, very strong and hard, close-grained, compact; dark brown in color; the sapwood light brown or yellow. It takes a beautiful polish, and is used for furniture and fuel, and in Nova Scotia and New Brunswick for shipbuilding. Birch beer is made from the sap of this species. In some parts of North Carolina considerable quantities of cherry birch have been cut for lumber.

Salix nigra, Marshall.

(WILLOW. BLACK WILLOW. RIVER WILLOW.)

A small tree, with a large oval crown, dark rough bark on the trunk, and smooth light brown bark on the spreading branches, reaching a height of 50 and a diameter of 2 feet, or towards its southeastern limit a mere shrub.

It occurs along streams from New Brunswick and Lake Superior south to Florida and Texas, and in the valleys of the Sacramento river, California, and the Colorado river, Arizona.



CHERRY BIRCH

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In North Carolina it is found from the coast to the mountains, growing on loamy soils along streams, and reaches a height of 30 feet and a diameter of 15 inches. It is rare in the high mountains, but in the Piedmont plateau is much more abundant.

Seed is borne abundantly and at frequent intervals, and seedlings are common on bottom lands. Trees of all sizes sprout from the stump. It is easily propagated from cuttings. The smaller branches and twigs are often injured by a saw fly, Cimbex americana.

The leaves are narrow, lance-shaped, toothed and tapering at the ends. The flowers appear in early spring in drooping catkins, the male and female on separate trees. The fruit is a pendulous catkin, made up of small capsules containing minute seeds which are clothed with long silky hairs. The roots are very fibrous and tough. The light, coarse-grained wood is soft, not strong, and brown in color; the sapwood much lighter. The bark is sometimes used medicinally.

Populus grandidenta, Michaux.

(POPLAR. ASPEN. LARGE-TOOTHED ASPEN.)

A tree, with a short body, pyramidal crown, and rather smooth gray bark, reaching a height of 80 and a diameter of 2½ feet.

It occurs in moist situations from Nova Scotia and New Brunswick westward through Ontario to northern Minnesota, south through the northern states, and along the Appalachian mountains to North Carolina, extending westward to middle Kentucky, and Tennessee.

In this State, where it reaches an average height of 40 feet and an average diameter of 12 inches, it is found in the upper part of the Piedmont plateau, but is not very common.

Although it bears seed frequently, young seedlings are uncommon. The rate of growth is uniformly rapid. The trunk is attacked by several borers and the leaves are often stripped off by caterpillars.

The leaves, which are borne on slender flattened stems are roundish, with 5 to 9 large blunt teeth on each side. The flowers appear before the leaves in spring in drooping cylindrical catkins, the sterile and fertile on separate individuals. The fruit is a catkin consisting of small dry capsules with minute seeds, coated with cottony down. The buds are conical and slightly downy.

The wood is light, soft, not strong, close-grained, and compact; light brown in color; the sapwood nearly white. It is used for wood pulp, and occasionally for turnery and woodenware.

Populus heterophylla, Linnæus.

(COTTONWOOD.)

A rare and local tree, with oval-oblong crown, dark gray bark, and lighter colored branches, reaching a height of 90 and a diameter of 3 feet.

It occurs on the borders of river swamps from Connecticut, generally near the coast, to Georgia and western Louisiana, and in Arkansas, Tennessee, Kentucky, Illinois, and Indiana, reaching its best development in the basin of the lower Ohio river.

In this State, where it attains an average height of 70 to 80 feet, it is found in the rich swamp lands of the lower Cape Fear river, and probably elsewhere.

The leaves are ovate, serrate with blunt incurved teeth, and downy on the veins beneath.

The wood is light, soft, not strong, close-grained, compact; dull brown in color; the thick sapwood lighter.

Populus monilifera, Aiton.

(CAROLINA POPLAR. CAROLINA COTTONWOOD.)

A large tree, with dark brown rough bark and oval crown, reaching a height of 170 and a diameter of 8 feet.

It occurs from Vermont to Florida, and westward to Montana, Colorado, and New Mexico, growing in low moist soil. It is common in the West.

In this State, where it reaches an average height of 60 to 70 feet, it is rare, and is found in the Piedmont plateau.

It bears seed frequently in North Carolina but never abundantly. Young trees are common on bottom lands along streams. Stumps over 18 inches in diameter sprout freely in the open.

The leaves are broadly ovate, and serrate with large incurved teeth. The winter buds are conical, shining brown, and of moderate size. The Carolina poplar has numerous strong lateral roots.

The wood is very light, soft, not strong, close-grained, compact, liable to warp, and hard to season ; dark brown in color ; the thick sapwood nearly white. It is used for paper pulp, packing cases, fence boards, and fuel.

Thuja occidentalis, Linnæus.

(ARBOR VITÆ.)

An evergreen tree, of pyramidal habit, with a rapidly tapering trunk furnished with numerous small branches at irregular intervals, reaching a height of 60 and a diameter of 5 feet, or at its southern limits reduced to a very small tree or shrub.

It occurs from New Brunswick to Lake Winnipeg, south to New York, Pennsylvania, Illinois, and Minnesota, and along the Appalachian mountains to North Carolina, growing on wet soil. It is very common in the North.

In this State, where it is but a shrub or small tree, it is confined to the mountains.

The small blunt-pointed or awl-shaped leaves are thickly pressed along the branchlets in 4 rows. The flowers are very minute. The light brown cones are ⅜ inch long, and each of the 6 to 12 oblong rounded scales protects 2 seeds.

The wood is very light, soft, not strong, brittle, and very durable in contact with the soil ; light brown in color ; the thin sapwood nearly white. It is used for fencing, telegraph poles, railroad ties, and shingles, and sometimes for cabinet work and building. An oil distilled from the leaves has been used in pulmonary complaints.

Cupressus thyoides, Linnæus.*

(WHITE CEDAR. JUNIPER.)

A slender evergreen tree, with numerous short spreading branches which cover the greater part of the trunk and form a conical head, and reddish-brown deeply furrowed or loose bark reaching a height of 90 and a diameter of 5 feet.

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*Chamæcyparis sphæroidea, Spach

It occurs in deep cold swamps from Maine along the coast to northern Florida and Mississippi, and is rare west of Mobile bay.

In this State, where it reaches an average height of 40 and an average diameter of 2 feet, it grows in wet sandy, often peaty, soils in the coastal plain region, extending westward to Wake and Anson counties. (Fig. 31) It frequently occurs in pure forest, or with the white bay, or scattered in small clumps, in cypress and gum swamps.

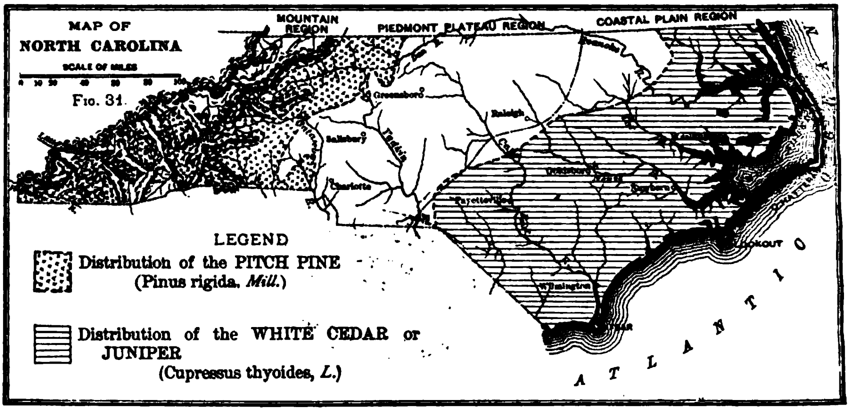
FIG. 31.

The juniper bears seed very plentifully nearly every year. Seedlings are common near the parent trees, but usually die under deep shade. Fire is very destructive to trees of all ages, and extensive areas of valuable timber have been burned, particularly in the Dismal Swamp. In many swamps large quantities of fallen trees, sound and fit for lumber, lie buried at various depths.

The leaves are very small, ovate-pointed, awl-shaped, and closely appressed in 4 rows. The male and female flowers are separate but on the same plant; the male catkins cylindrical, the female globose. The cones are very small and globular, with thick scales bearing 2 or more seeds at the base. The juniper, at least in peaty swamps, has a poorly developed tap-root or none at all, and long strong superficial lateral roots.

The wood is very light and soft, not strong, close-grained, com-

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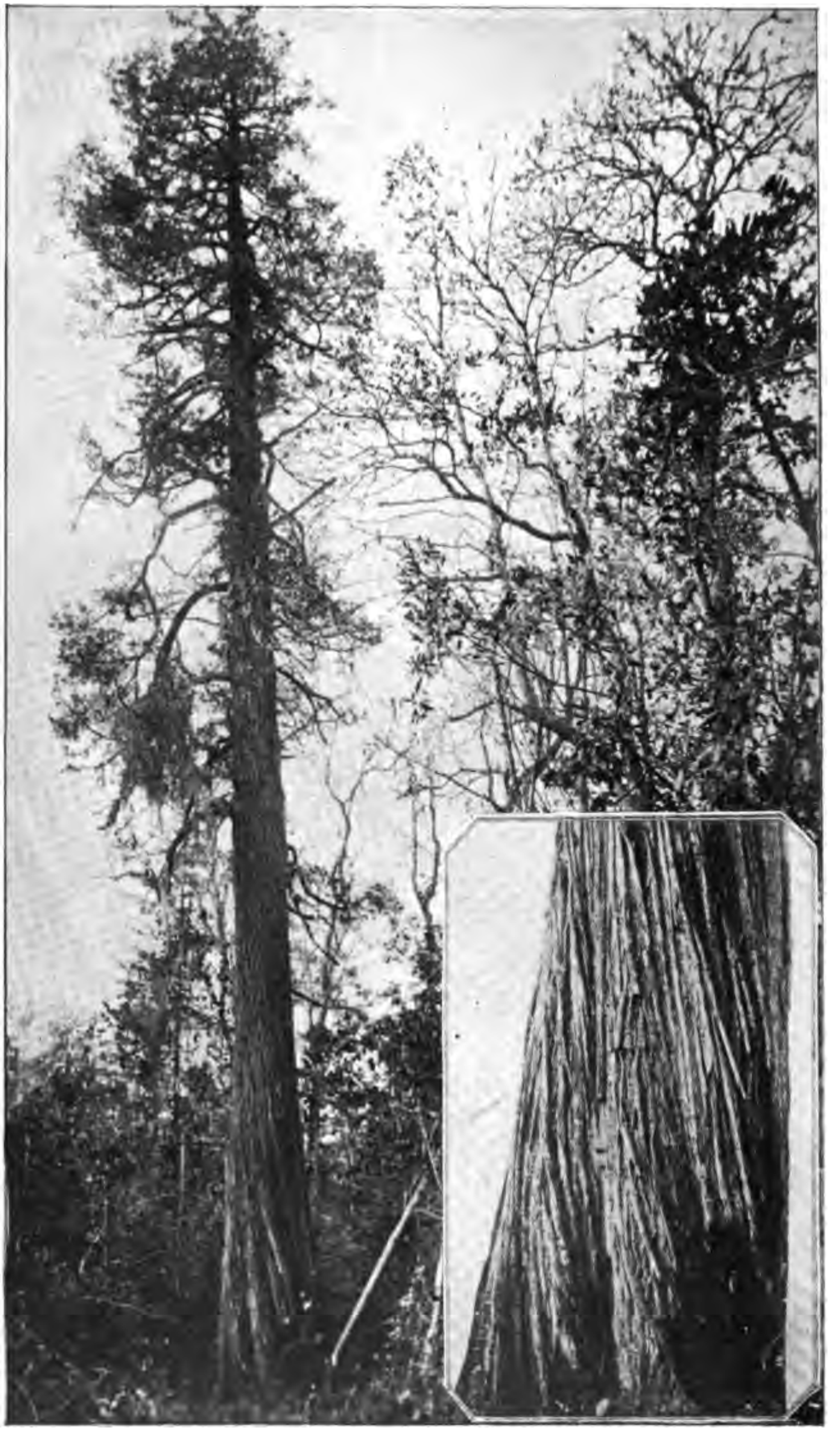


RED CEDAR

pact, easily worked, and very durable in contact with the soil; light brown in color; the sapwood lighter. It is used for boat-building, woodenware, cooperage, shingles, interior finish, telegraph posts, fence posts, railway ties, and in the manufacture of lampblack. Charcoal for gunpower is made from the smaller trunks.

The original growth, in most accessible juniper swamps of this State, is being rapidly removed. There still remain, however, large quantities in Dare, Tyrrell, and Gates counties and in the Dismal Swamp, which are yet inaccessible.

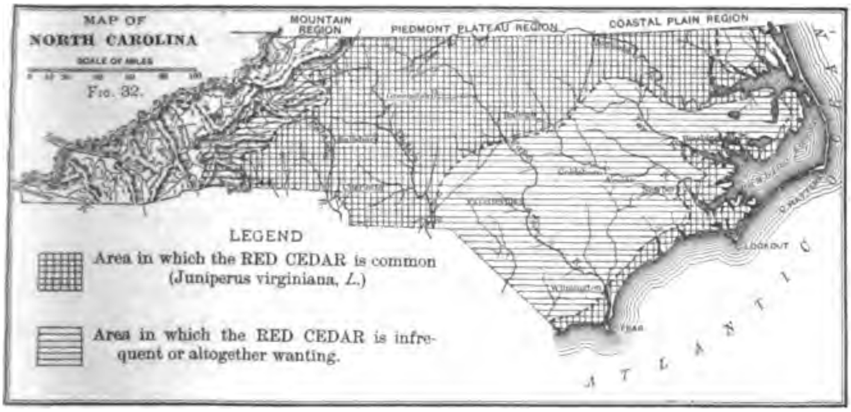
Juniperus virginiana, Linnæus.

(RED CEDAR.)

An evergreen tree, with pyramidal head, numerous crowded drooping branches, and dark brown shaggy bark, reaching a height of 100 and a diameter of 6 feet, or at its northern and western limits often reduced to a low shrub. (Plate XIII.)

It is one of the most widely distributed North American trees, and occurs in all parts of the United States except western Texas, California, and Oregon; reaching its best development in the valley of the Red river, Texas.

In North Carolina, where it grows to an average height of 30 to 40 feet, and an average diameter of 10 to 13 inches, it is found throughout, but is rare and of small size in the high mountain counties. (Fig. 32.)


MAP OF
NORTH CAROLINA
SCALE OF MILES
FIG. 32.
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
LEGEND
▦ Area in which the RED CEDAR is common (Juniperus virginiana, L.)
▤ Area in which the RED CEDAR is infrequent or altogether wanting.
LOOKOUT
ATLANTIC

The red cedar bears seed abundantly nearly every year. Young trees frequently form a large part of the growth on dry rocky fields and hillsides, particularly in the Piedmont plateau region. Young growth is often overtopped and crowded out by faster growing pines and oaks, although it can live in deep shade for a long time. Small specimens are very sensitive to fire. It is very free from the attacks of insects and from all fungal diseases.

The leaves are small, entire, scale-like, and sharp-pointed or obtuse. The flowers are small and inconspicuous, and the fruit is a small ovate smooth berry, dark purple, and covered with a glaucous bloom. On deep loamy soil the red cedar has a well developed tap-root and numerous deeply seated lateral roots.

The wood is light, soft, not strong, brittle, very close and straight-grained, compact, easily worked, and durable in contact with the soil; dull red in color; the thin sapwood nearly white. It is used for posts, sills, railroad ties, interior finish, cabinet making, woodenware, and for lead pencils to the exclusion of all other woods. The wood is odorous, and an infusion of the berries is used medicinally.

Taxodium distichum, Richard.

(CYPRESS. BALD CYPRESS.)

A large tree, of great commercial value, with deciduous leaves, a small flat spreading or pyramidal top, and deeply furrowed or loose reddish-brown bark, reaching a height of 150 and a diameter of 13 feet.

It occurs in wet situations from Delaware to Florida and Texas, and in Arkansas, Kentucky, Missouri, Illinois, and Indiana; reaching its best development in the south Atlantic and Gulf states. It is common and forms extensive forests.

In North Carolina, where it reaches an average height of 60 to 100 and an average diameter of 5 to 7 feet it occurs in the coastal plain region (fig. 33), where it is one of the most common trees along streams and swamps. It is found on a variety of soils between a heavy mud-alluvium and a light sand or rarely on peaty soil.

Although seed years are frequent, young plants are not common.

A growth of gums usually follows the cypress after lumbering. Large specimens have swollen butts which are often hollow. The timber has frequently small hollows and rotten spots scattered through apparently sound logs.

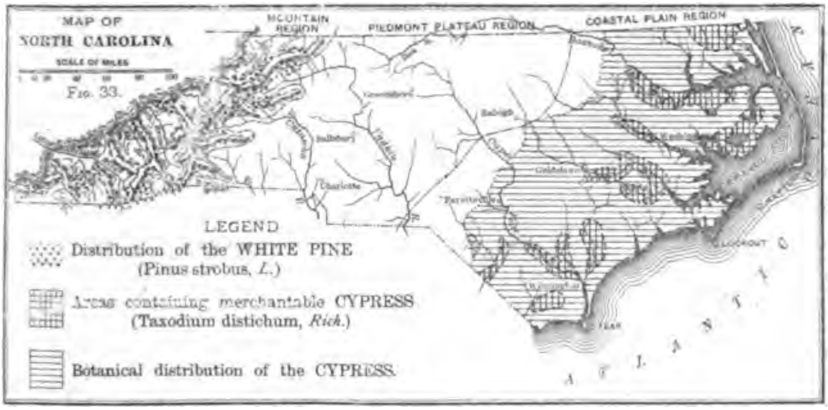


Fig. 33.

The leaves are deciduous, flat, linear, and in two rows on the slender branchlets. The male and female flowers are borne on the same tree; the male in drooping flexible catkins, the female in ovoid catkins, singly or in small clusters. The fruit is a small dark brown globular cone with thick scales. There are many deeply penetrating lateral roots, and long superficial roots from which the "cypress knees" grow to a height of one to four feet.

The wood is light, soft, close and straight-grained, not strong, compact, easily worked, and very durable in contact with the soil; light or dark brown in color; the sapwood nearly white. The lumber is known commercially in two varieties, the black and white cypress, of which the former is heavier, harder, and more durable. It is used for construction, cooperage, railroad ties, fencing, shingles, water pipes, and interior finish.

Much of the cypress has been removed along the larger streams and from the more accessible swamps in the northeastern counties for the manufacture of lumber and shingles. Large quantities, however, are still standing in the State.

Pinus strobus, Linnæus.

(WHITE PINE.)

A large tree, of the first commercial importance, with horizontal branches, and rough furrowed dark grayish-brown bark, reaching a height of 170 and a diameter of 11 feet. (Plate XIV.)

It occurs from Newfoundland to the Winnipeg river, south through the northern states to Pennsylvania, Michigan, Illinois, Iowa, and along the Appalachian mountains to Georgia; reaching its best development in the region of the Great Lakes.

In this State, where it attains an average height of 60 to 70 and an average diameter of 2½ feet, it is confined to the mountains. It grows for the most part at an elevation of 1,500 to 3,500 feet, and is found along the Blue Ridge, and scatteringly in the counties west of it. (Fig. 33, p. 123.)

The white pine bears seed at intervals of from 2 to 4 years. Seedlings are common in open woods, and in old fields on dry poor soil. It prefers a sandy loam, but is found on clay and on sandy soil. It grows usually on rich land or on high dry stony ridges, and often forms large patches of nearly pure forest. The growth is slow for the first 4 to 7 years, then very rapid for 40 to 60 years, after which it again grows slowly. It is a long-lived tree, sound specimens having been found 350 or 400 years old. Specimens under 10 inches in diameter are sensitive to fire.

In the northern states the grub of the pine borer or sawyer, Monohamnus confusor, Kirby, attacks the sound timber, though less frequently than that of decaying trees. The white pine weevil, Pissodes strobi, Peck, causes a great deal of injury by entering and destroying the leaders. This species is also subject to the attack of the grubs of various bark beetles.

The leaves are soft, slender, in fives. The male catkins are oval, the female long-stalked and cylindrical; the cones long, narrow, slightly curved, and tapering to a point. The seeds are small, smooth, and ovate, with thin wings about 1 inch long. The roots, which are remarkable for their durability, usually do not penetrate deeply into the soil.

The wood is light, soft, not strong, very close and straight-grained, compact, easily worked; light brown in color; the sapwood nearly white. It is used for lumber, shingles, laths, building material, cabinetmaking, interior finish, matches, woodenware, and domestic purposes, and is altogether one of the most

A GROUP OF WHITE PINES

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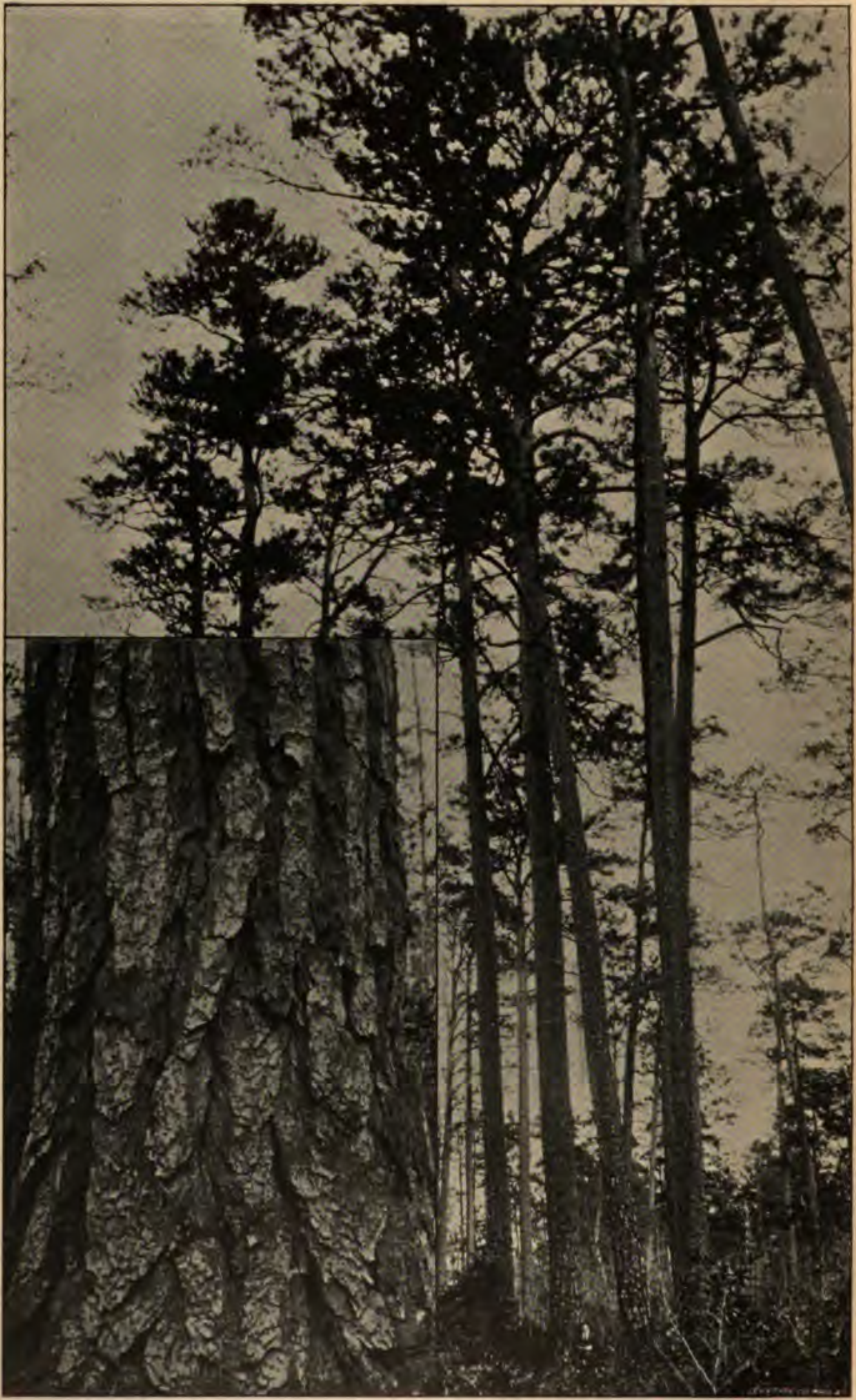

A GROUP OF LOBLOLLY PINES

useful timbers of the United States. Its threatened exhaustion is therefore a serious matter.

Pinus tæda, Linnæus.

(LOBLOLLY PINE. OLD FIELD PINE. SHORT-LEAF PINE. SWAMP PINE. SLASH PINE. ROSEMARY PINE. NORTH CAROLINA PINE.)

A large and valuable tree, with a long clear stem, a large ovoid crown, and reddish-brown bark divided into flat rectangular plates, reaching a height of 150 and a diameter of 5 feet. (Plate XV.)

It occurs from Delaware to Florida and Texas, generally near the coast, and north to the valley of the Arkansas river; reaching its best development in eastern North Carolina.

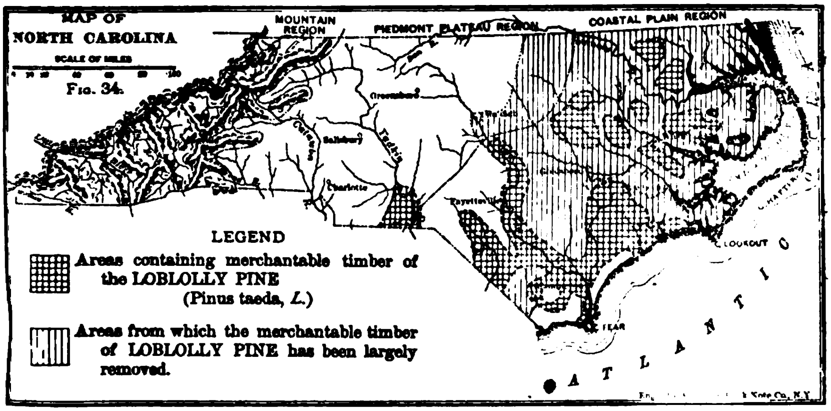
Fig. 34.

In this State (fig. 34), where it attains an average height of 50 to 70, and an average diameter of 2 to 3 feet, it is found on a great variety of soils and situations from the sea level to an elevation of 1,000 feet. The original growth is on moist deep soil, but the second growth has sprung up largely in old fields, often replacing the long-leaf pine on the moister loamy lands.

It bears seed generally every year, and abundantly once in 2 or 3 years, but much of the seed is imperfect. Seedlings are very common on rather moist soil in abandoned fields. The rate of growth, under sufficient light, is very rapid.

The slender light green leaves are usually in threes, with rather long close sheaths. The cones are ovate-oblong and 3 to 4 inches long; the scales terminate in short rigid spines. This species has a tap-root and many strong deeply penetrating lateral roots.

The wood is light, not strong, brittle, very coarse-grained and not durable; light brown in color, the very thick sapwood orange or often nearly white. It is used for lumber and fuel. Turpentine is sometimes obtained from this tree.

Pinus rigida, Miller.

(PITCH PINE. BLACK PINE.)

A tree, with an oblong crown, spreading branches, a cylindrical, and often crooked stem, and rather flaky dark reddish-brown bark, reaching a height of 80 and a diameter of 3 feet.

It occurs from New Brunswick to the northern shores of Lake Ontario, south through the Atlantic states to northern Georgia, and westward to West Virginia and Kentucky. A very common tree.

In this State, where it reaches an average height of 50 to 70 feet and an average diameter of 18 to 24 inches, it is found in the western part of the Piedmont plateau region and in the mountain counties south of the French Broad river. (Fig. 31, p. 120.) It grows on dry, often sandy or gravelly ridges, mixed with the short-leaf and scrub pines.

It produces seed often and in abundance, and the seedlings, which require a good deal of light, are common in dry open situations, and in old fields. Young trees sprout from the stump to some extent, but the sprouts are short-lived. The resistance of the pitch pine to fire is exceptionally great.

The rigid flattened leaves are usually in threes, from short sheaths, and 3 to 5 inches long. The cones are ovate and from 2 to nearly 4 inches long, the scales armed with a short recurved spine.

The wood is light, soft, not strong, brittle, and coarse-grained; light brown or red in color; the thick sapwood yellow or often

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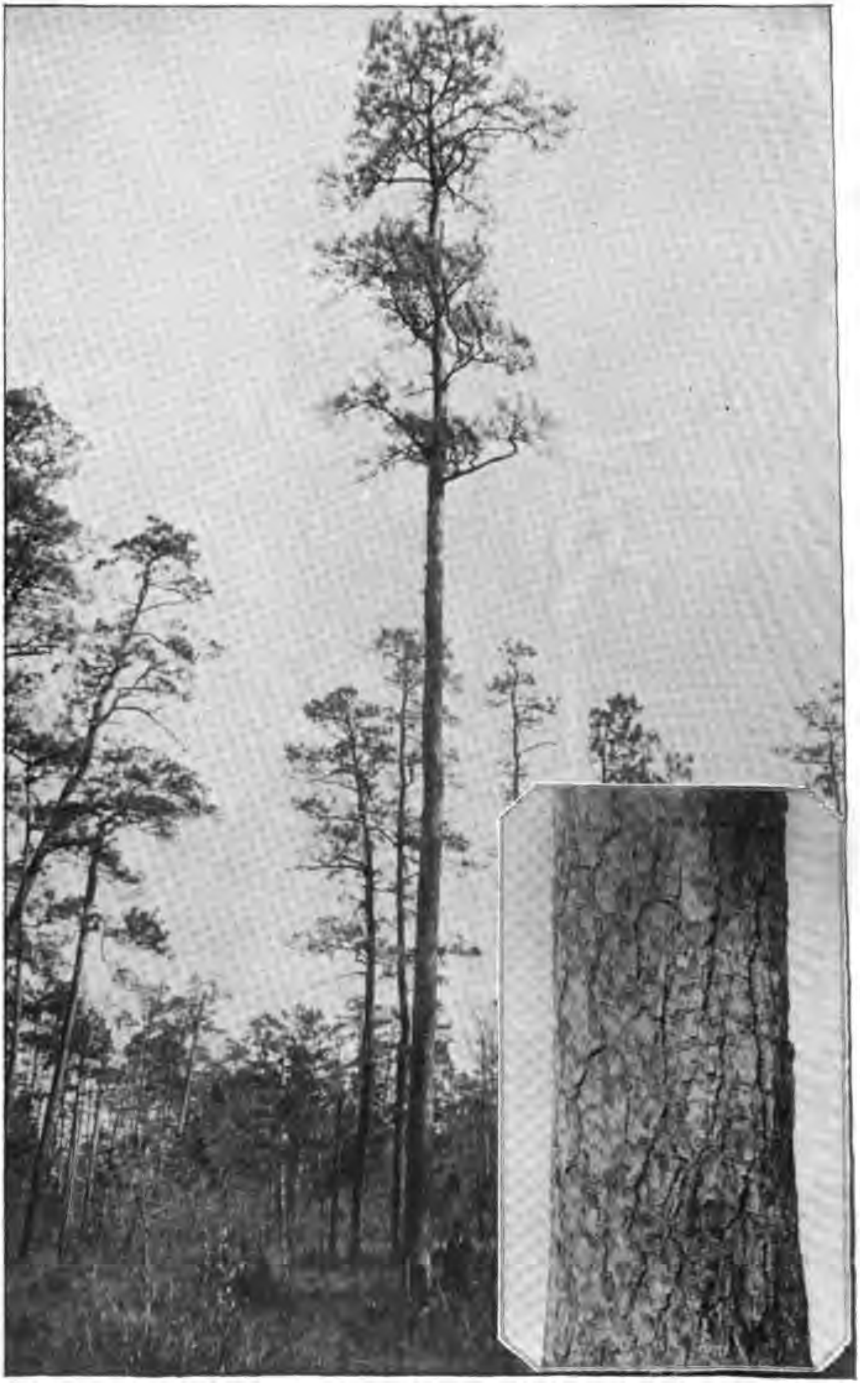

POND OR SAVANNAH PINE

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nearly white. It is used for fuel, charcoal, and coarse lumber. It has been sparingly cut for lumber in North Carolina.

Pinus serotina. Michaux.

(POND PINE. SAVANNA PINE. SWAMP PINE. POCOSIN PINE.)

A small tree, with a short cylindrical trunk, numerous short branches, and smooth dark brown bark broken into rectangular plates, reaching a height of 80 and a diameter of 3 feet. (Plate XVI.)

It occurs on low peaty or wet sandy soils of the worst quality, from North Carolina to Florida, near the coast.

In this State, where it reaches an average height of 40 to 50 feet, it is common in the small swamps of the coastal plain, and is occasionally found in the Piedmont plateau region. (Fig. 35.)

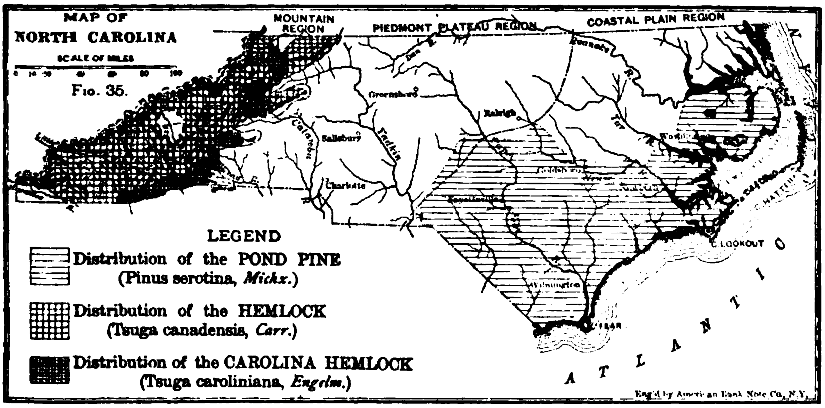

FIG. 35.

It bears seed frequently, and young growth is common on wet soil near old trees and mixed with the second growth of loblolly pine. A great deal of the seed will not germinate. It is more sensitive to fire than the loblolly pine. Old specimens are often hollow or red-hearted.

The leaves are in threes, 5 to 8 inches long, somewhat shorter and from shorter sheaths than those of the loblolly pine. The cones frequently remain on the tree several years before dropping their seed. They are round-ovate, 2 to 3 inches long, with scales rounded at the apex and have a small weak prickle.

The wood is heavy, soft, not strong, brittle, coarse-grained; dark orange in color; the thick sapwood pale yellow.

In some sections of the State the pond pine is manufactured into lumber with the loblolly, from which it is not distinguished commercially.

Pinus virginiana, Miller.*

(JERSEY PINE. CEDAR PINE. SPRUCE PINE. SCRUB PINE.)

A slender tree, with a short stem, very numerous limbs which form an open oval or conical crown, and red-brown frequently scaly bark, reaching a height of 120 and a diameter of 3 feet.

It occurs from New York, generally near the coast, to Georgia, and westward to Kentucky, and Indiana; reaching its best development west of the Appalachian mountains.

In this State, where it grows to a height of 20 to 40 feet and a diameter of 12 to 15 inches, it occurs sparingly in the Piedmont plateau on gravelly ridges with the short-leaf pine, and along the foot and on the spurs of the Blue Ridge much more abundantly, mixed with the white and pitch pines, or sometimes forming small patches of pure forest. It is also found west of the Blue Ridge. (Fig. 36.)

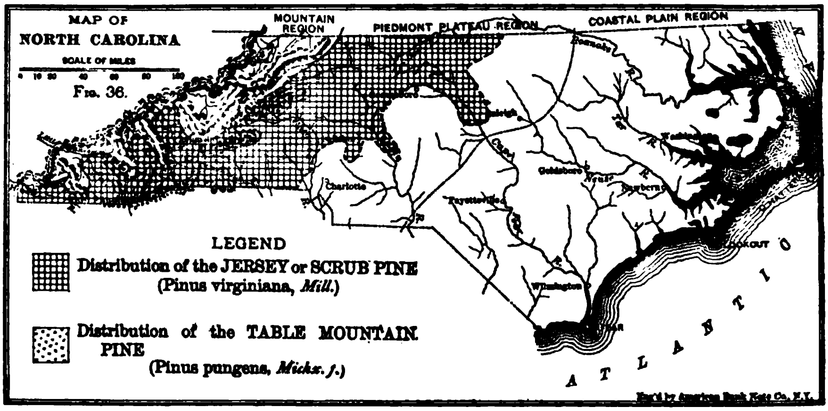
Fig. 36.

Seed is produced plentifully once in 2 or 3 years, and seedlings are very common, particularly in old fields, together with those of the short-leaf pine. The rate of growth is very rapid, but the tree is short-lived.

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*Pinus inops, Aiton.

The leaves are short, 2½ to 3 inches long, rigid, in short sheaths, and usually in twos. The cones are light brown, solitary, curved, and oblong-conical, the scales armed with a rigid prickle. The root system is inclined to be somewhat heart-shaped, with a well developed tap-root.

The wood is light, soft, not strong, brittle, close-grained and durable; light orange in color; the thick sapwood nearly white. It is used for fuel, water pipes, and pump logs. In North Carolina it is used in the manufacture of charcoal, and to some extent for fencing.

Pinus pungens, Michaux.

(TABLE MOUNTAIN PINE.)

A tree, with rough reddish-brown bark and a large spreading crown, reaching a height of 60 and a diameter of 3½ feet.

It occurs along the Alleghany mountains from Pennsylvania to Tennessee, where it reaches its best development. A common tree, sometimes forming pure forest.

In North Carolina it attains an average height of 30 to 50 feet, and an average diameter of 12 to 20 inches, and is found only along the Blue Ridge and the ranges immediately eastward on the driest, most barren ridges, usually associated with the pitch pine, and the chestnut and scarlet oaks. It is most abundant in the southeastern parts of Macon and Jackson counties. (Fig. 36, p. 128.)

It bears seed abundantly; seedlings are common in open woods near the old trees, and in abandoned fields.

The leaves are 2 to 2½ inches long, stout, and generally in twos. The light yellow very compact cone, 3 inches long and 2 inches broad at the base, has very broad strong sharp spines, 1-6 inch long, bent toward the top of the cone.

The wood is light, soft, not strong, brittle, coarse-grained; light brown in color; the thick sapwood nearly white. It is used for charcoal and to some extent in construction.

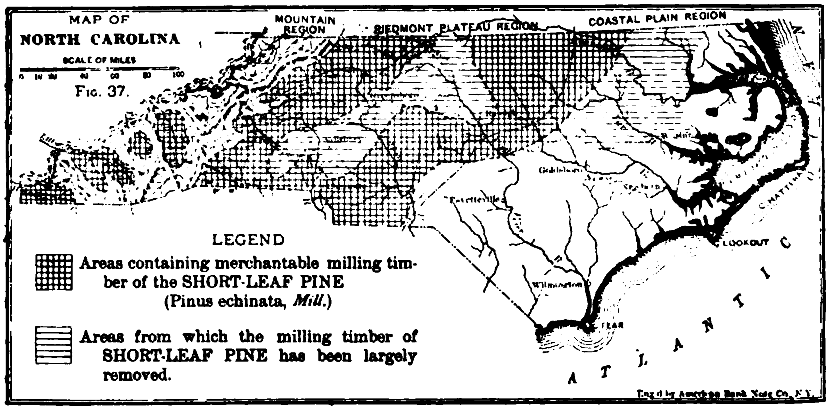
Pinus echinata, Miller.*

(SHORT-LEAF PINE. YELLOW PINE. SPRUCE PINE. ROSEMARY PINE. HEART PINE.)

A tree of commercial importance, with a long clear stem, a broad oval crown, and brownish-red bark broken into rectangular plates, reaching a height of 100 and a diameter of 4½ feet.

It occurs from New York to Florida and Texas, through Arkansas to Indian Territory, Kansas, and Missouri, and in Illinois; reaching its best development in Louisiana, Arkansas and Texas.

In North Carolina, where it grows to a height of 70 to 90 feet and a diameter of 2 to 3½ feet, it is found throughout, and enters into the composition of most upland forests. It appears less commonly in the coastal plain region, being especially rare south of the Neuse river. (Fig. 37.)


MAP OF
NORTH CAROLINA
SCALE OF MILES
0 10 20 40 60 80 100
FIG. 37.
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
Goldsboro
Fayetteville
Wilmington
LOOKOUT C
FEAR
A T L A N T I
LEGEND
Areas containing merchantable milling timber of the SHORT-LEAF PINE (Pinus echinata, Mill.)
Areas from which the milling timber of SHORT-LEAF PINE has been largely removed.
Eng'd by American Bank Note Co. N.Y.

The short-leaf pine produces some seed annually, and bears abundantly about once in three years. Seedlings are common on well-drained soil, occupying abandoned fields and often growing in mixture with the loblolly pine. The rate of growth in youth is very rapid. On high exposed situations it is sometimes thrown by the wind.

The dark green slender leaves are usually in twos, from a long sheath, and 3 to 5 inches long. The cone, smaller than that of the other North Carolina pines, and armed with slender short

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*Pinus mitis, Michaux.

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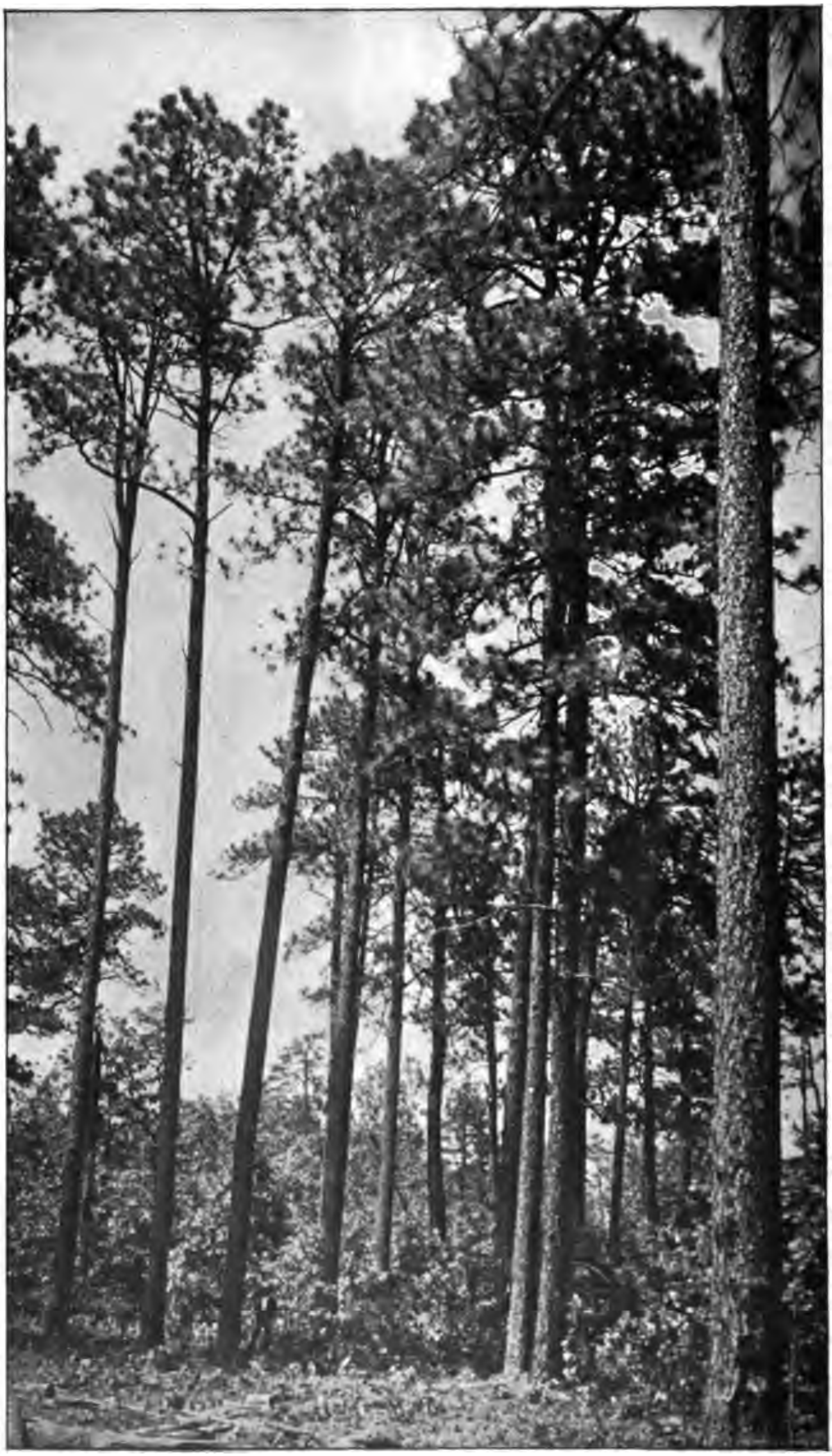

A GROUP OF LONG-LEAF PINES

spines, is rarely 2 inches long. It has a strong tap-root and several lateral roots.

The wood varies greatly in quality and in the amount of sapwood. It is heavy, hard, strong, and generally coarse-grained; orange in color; the sapwood nearly white. It is much used for lumber, for which purpose it is only inferior to that of the long-leaf pine.

In the middle sections near the railroad it has been largely removed. Large quantities still remain, however, in Stanly, Cabarrus, Randolph, Caswell, Davidson, Surry, Wilkes, Alexander, Iredell, Yadkin, Cleveland, Rutherford, and Caldwell counties. The amount sawed in this State in 1894 probably was between 50,000,000 and 60,000,000 feet, board measure, the larger part of which was for local use.

On account of its tendency to spring up in old fields and open woods, and the excellent quality of its timber, the short-leaf pine is probably destined to assume very extensive economic importance in the future.

Pinus palustris, Miller.

(LONG-LEAF PINE.)

A tree of the first commercial value, with a long slender trunk free from branches, a small round head, and thin bright red-brown thin-scaled bark, reaching a height of 95 and a diameter of 4 feet. (Plate XVII.)

It occurs from Virginia to Florida and Texas, rarely beyond 150 miles from the coast, and reaches its best development in northeastern Texas on the gravelly uplands of the valleys of the Sabine and Trinity rivers.

In North Carolina, where it reaches an average height of 70 feet and an average diameter of 15 to 20 inches, it is found (fig. 38) in pure forest from the Neuse river southward, occupying all the highest and driest sandy lands from the coast to within a few miles of Troy, in Montgomery county, and Rockingham, in Richmond county. Only along its western limits does it occur associated to any extent with other trees. The long-leaf pine formerly extended in an almost unbroken forest to Virginia, but it has been either entirely cut out or so much thinned that it is of little commercial value north of the Neuse river. The loblolly pine has for the most part taken its place, except on very dry and sterile soils.

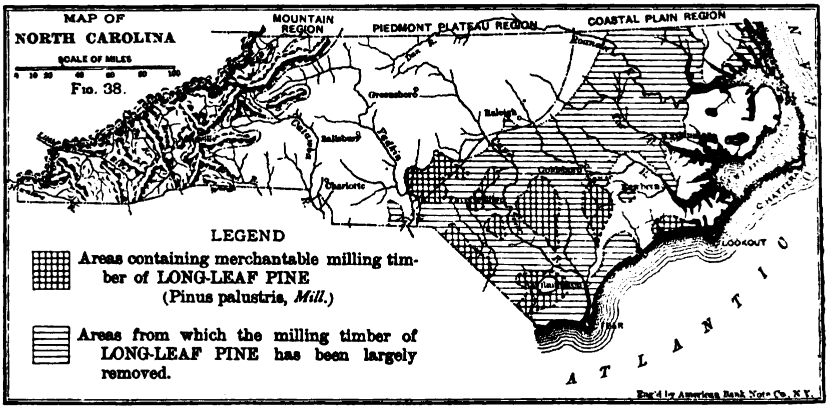
Fig. 38.
MAP OF
NORTH CAROLINA
SCALE OF MILES
0 10 20 40 60 80 100
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
Greensboro
Raleigh
Salisbury
Charlotte
Dan R.
Roanoke
Yadkin
Catawba
LOOKOUT
HATTERAS
ATLANTIC
LEGEND
Areas containing merchantable milling timber of LONG-LEAF PINE (Pinus palustris, Mill.)
Areas from which the milling timber of LONG-LEAF PINE has been largely removed.
Eng'd by American Bank Note Co. N.Y.

The long-leaf pine bears seed very abundantly only at long and irregular intervals. A fair production of seed occurs about once in 5 years, while in the intermediate years the yield is small and localized. After a seed year the young plants are very abundant throughout the woods, but are killed in large numbers either by forest fires, by the dense shade, or by swine rooting them up to devour the sweet tender roots. Young trees are very sensitive to fire. After the first four or five years trees in the open grow very rapidly until about 15 years old, particularly in height, after which time the growth is slow. When the long-leaf pine is cut or burned, and prevented from reproducing itself on account of fires and swine, the loblolly pine often follows on damp soils, and scrub oak or fork-leaved black-jack oak on high dry sandy lands.

The timber loss by fire on long-leaf pine lands in 1893 amounted to not less than $100,000. At rare intervals extensive tracts are destroyed by bark beetles. Scattered trees are injured in localities where the dead tops have been left in the woods after lumbering. Beetles attack trees which have been injured by turpentine operations, which often so weaken them that many are thrown by the wind. In 1893 the losses, principally through this cause, amounted to between ten and fifteen million feet, board measure.

The leaves are 10 to 15 inches long, in threes from long sheaths,

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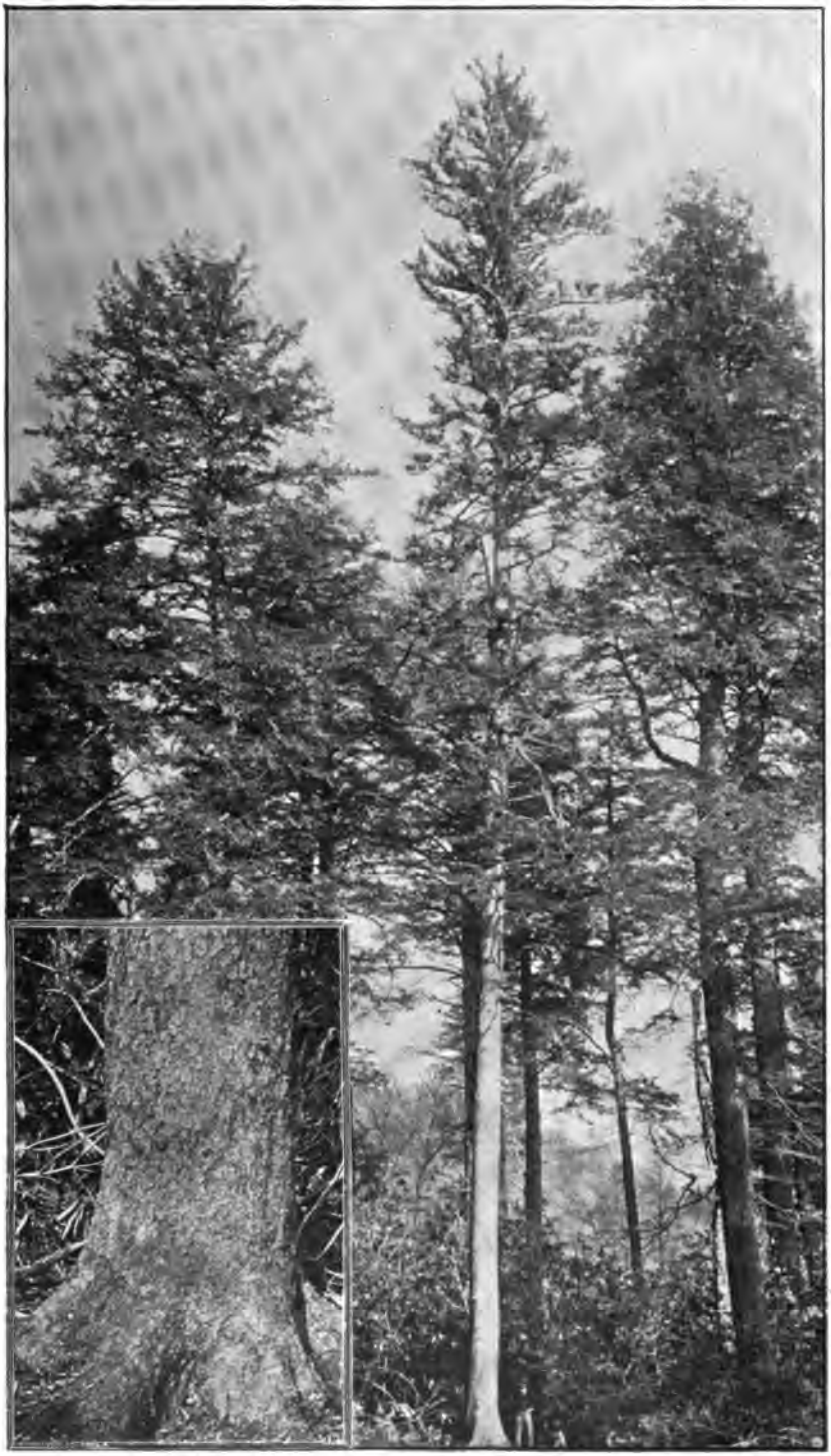


HEMLOCK

BLACK SPRUCE

and clustered on the ends of the thick scaly branchlets. They remain on healthy trees about 3 years, but on boxed trees only about two. The sterile flowers are rose colored, appearing about the first of April, and the large silky winter buds are white. The cones are light brown, cylindrical or conical-oblong, 6 to 10 inches long, and have thick scales armed with a stout blunt spine. A tap-root is developed in early life and is often forked. The root system of old trees tends to be heart-shaped with the lateral roots penetrating deeply.

The wood is heavy, hard, strong, tough, coarse-grained, and durable; light red or orange in color; the thin sapwood nearly white. It is widely used for construction of all kinds, interior finish, fencing, railroad ties, etc. Turpentine, tar, pitch, rosin, and spirits of turpentine are obtained almost exclusively from this species.

The largest bodies of standing long-leaf pine are in Moore, Montgomery, Cumberland, Robeson, and Bladen counties, and probably not more than 50,000 acres still remain unboxed. Wilmington has for a long time been an important centre for the manufacture of lumber from this species, and much has also been cut in the Aberdeen district in Moore and Cumberland counties.

Picea nigra, Link.

(BLACK SPRUCE. HE BALSAM. LASH HORN. TAMARAC.)

A tree, with spreading branches which form a conical crown, a long cylindrical trunk, and dark brown scaly bark, reaching a height of 90 and a diameter of 4 feet. (Plate XVIII.)

It occurs from Newfoundland to Hudson bay, the mouth of the Mackenzie river, and the eastern slopes of the Rocky mountains, and south through the northern states to Pennsylvania, Michigan, Wisconsin and Minnesota, and along the Appalachian mountains to North Carolina.

In this State, where it is confined to the upper slopes of the highest peaks, above an elevation of 5,000 feet, from Elk Knob in Ashe to Clingman's Dome in Swain county, it forms pure forest or toward the summits is mixed with Carolina fir and beech, and reaches an average height of 40 to 50 feet and an average diameter of 15 to 20 inches. In favorable localities at its lower limits, it attains a height of nearly 100 and a diameter of 4 feet.

It bears seed in abundance, in this State, only at long and irregular intervals. Young growth, however, is common in the thick woods.

Great quantities of spruce have been destroyed by bark beetles, notably in Maine and in the Adirondack mountains of New York. A bud worm, Tortrix fumiferana, Clemens, which attacks the shoots and foliage, is one of its most deadly enemies.

The dark green needle-shaped rigid leaves are scattered on all sides of the slightly downy branchlets. The cones are ovate or ovate-oblong and 1 to 1½ inches long, with thin roundish scales.

The wood is light, soft, not strong, close and straight-grained; light red, or often nearly white in color; the sapwood lighter. It is used for construction, shipbuilding, piles, posts, railroad ties, etc. Spruce beer is made from this species.

The largest bodies of spruce, in North Carolina, are on the Black mountains in Yancey county, Grandfather mountain in Watauga, the Balsam mountains in Haywood, and the Great Smoky mountains in Swain county.

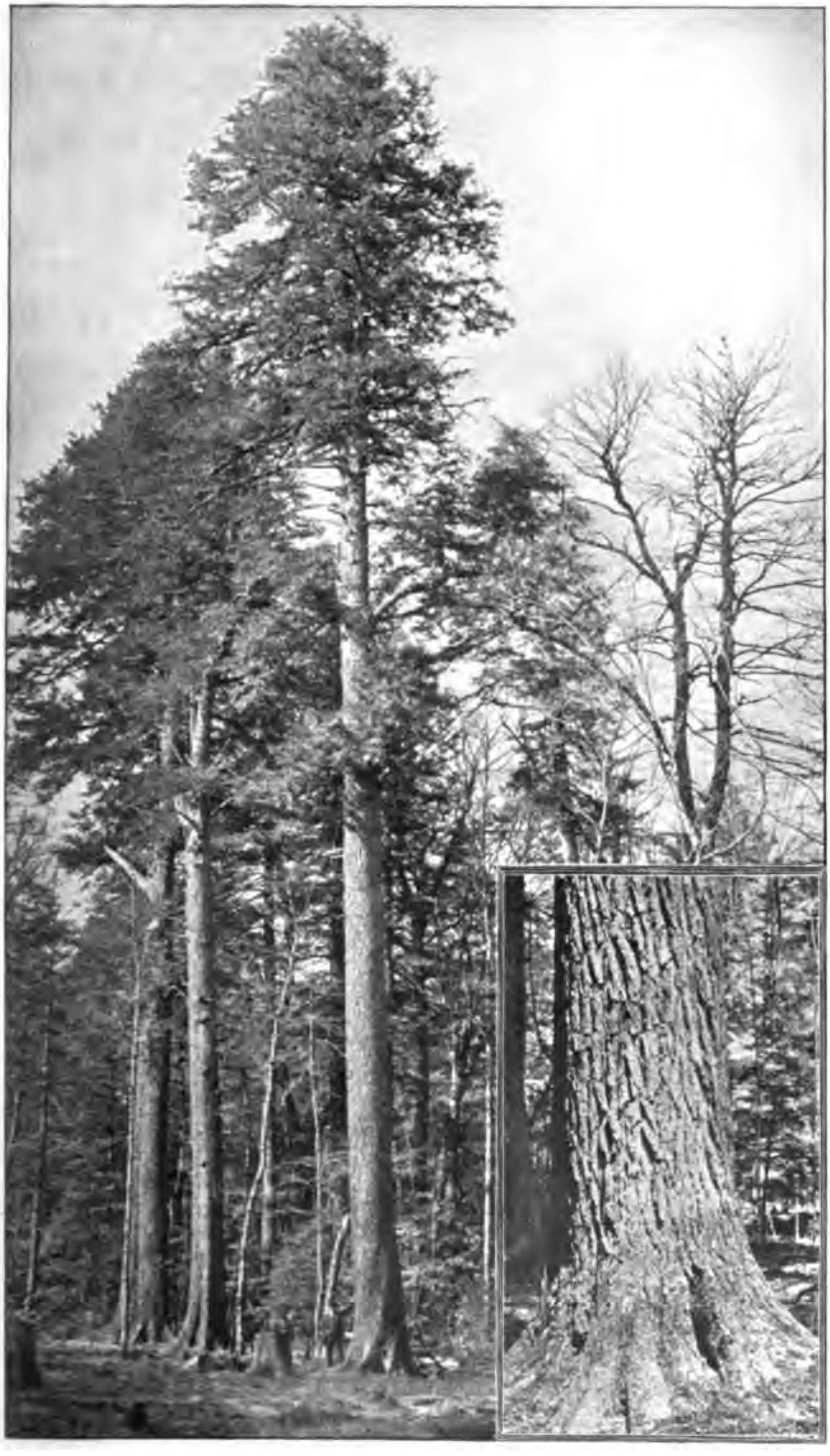
Tsuga canadensis, Carrière.

(HEMLOCK. SPRUCE PINE.)

A large tree, with a large conical crown, numerous spreading branches, and dark red-brown deeply furrowed bark, reaching a height of 110 and a diameter of 6 feet. (Plate XIX.)

It occurs generally on northern slopes from Nova Scotia to northern Wisconsin, and south to Delaware, Michigan, central Wisconsin, and along the Appalachian mountains to Alabama; reaching its best development in the high mountains of North Carolina and Tennessee.

In North Carolina, where it attains an average height of 70 to 80 and an average diameter of 2 to 3 feet, it is common in the mountains in cool ravines along streams on loamy or rich vegeta-



HEMLOCK

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ble soil, associated with cherry birch, yellow birch, and the Rhododendron. (Fig. 35, p. 123.)

It bears seed frequently, and young seedlings are common in the shade of the old trees. The hemlock is very free from the attack of injurious insects. Tall trees in exposed situations are often thrown by the wind.

The dark green leaves are linear, flat, obtuse, two-ranked, and whitish beneath. The cones are small, oval or oblong, with the scales smooth and entire. The hemlock has numerous spreading lateral and superficial roots.

The wood is light, soft, not strong, brittle, coarse and crooked-grained, difficult to work, liable to windshake and splinter, and not durable ; light brown or often nearly white in color ; the sapwood somewhat darker. Commercially two varieties, the red and the white, are recognized. The coarse lumber is used for construction, outside finish, and railroad ties. The bark is extensively employed for tanning, and yields a powerful astringent. Canada or hemlock-pitch is made from this species.

A good deal of hemlock has been cut near Cranberry for the bark, and large quantities of logs have been floated down the branches of the Tennessee river from Graham and Swain counties to Knoxville, Tenn.

Tsuga caroliniana, Engelmann.

(CAROLINA HEMLOCK. HEMLOCK. SPRUCE PINE.)

A tree, with conical crown, numerous branches upon two-thirds of the stem, and rough thick red-brown bark, reaching a height of 50 to 70 and a diameter of 2 to 3 feet.

It is found locally along the eastern Appalachian mountains from the Saluda mountains, South Carolina, to Ashe county in North Carolina, where it occurs on cliffs along the South Fork of the New river, near Elk Cross-roads, and on spurs of the Blue Ridge ; also in the gorge of the Doe river in Carter county, Tenn. (Fig. 35, p. 123.) It grows on dry and rocky ridges, rarely forming pure forest.

The Carolina hemlock bears seed frequently, but usually not in abundance. Seedlings are common in dense woods.

The leaves are longer and more scattered than those of the common hemlock, to which the tree bears a general resemblance. The cones are larger, drooping, and with spreading scales.

The coarse-grained brittle wood is light and soft; light brown tinged with red; the sapwood nearly white.

Abies fraseri, Lindley.

(BALSAM.)

A tree, with conical crown, numerous spreading branches, and light gray rather smooth bark, reaching a height of 80 and a diameter of 2 feet.

It occurs on moist slopes at an elevation of 5,000 to 6,500 feet, upon the mountains of North Carolina and Tennessee, often forming considerable forests.

In this State, where it reaches an average height of less than 40 feet and an average diameter of 12 to 15 inches, it is common on the highest summits of the mountain region, but it does not occur below 4,000 feet. It usually forms pure forest, but is found mixed with the black spruce, and to a less extent with beech and the birches.

It bears seed at rather long intervals, but seedlings are common under the shade of the old trees. The growth in youth is rapid.

The leaves are somewhat two ranked, linear, flattened and obtuse, and remain on the trees for several years. The cones are 1 to 2 inches long.

The wood is very light, soft, not strong, coarse-grained; light brown in color; the sapwood nearly white. It is little used. A thin, clear liquid called turpentine or balsam, derived from blisters on the bark, is used for cuts and sores.

Sabal palmetto, Loddiges.

(PALMETTO.)

An endogenous tree, destitute of branches, with a small oval or

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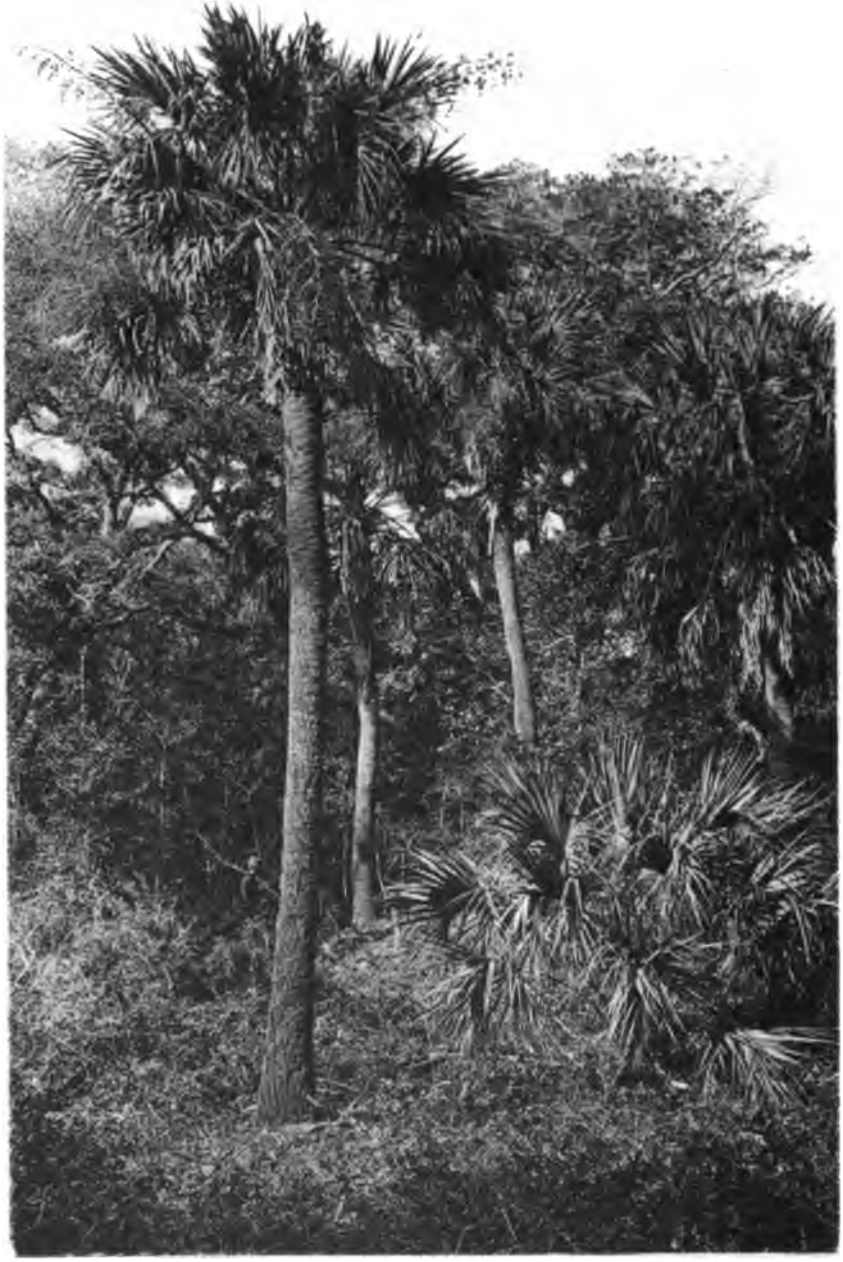

LIVE OAKS. A YOUNG PALMETTO.

A GROUP OF PALMETTOS. SMITH'S ISLAND.

globose head formed of the large round leaves, and rough furrowed dark brown bark, reaching a height of 40 and a diameter of 3 feet. (Plate XX.)

It occurs from Smith Island off Cape Fear river, North Carolina, to Key Largo, Florida, and along the Gulf coast to the Appalachicola river; reaching its best development on the west coast of Florida, south of Cedar Keys.

In North Carolina, it is found on deep sandy or loamy soil with the live oak, American olive, and water oak, and attains a height of 30 feet and a diameter rarely exceeding 18 inches. Its rarity renders it of little commercial importance.

The leaves are large, fan shaped, palmated, and borne on stems 18 to 24 inches long. The flowers are small, greenish, and in small clusters, and the fruit is a small rounded drupe.

The wood is light and soft; light brown in color; the fibrovascular bundles hard, dark, and difficult to work. It is impervious to the attacks of the teredo, very durable in water, and is largely used for piles and wharves. The inner portion of the young plant is edible, and is often pickled.

FORESTS OF NORTH CAROLINA.

BY

WILLIAM WILLARD ASHE.

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THE FORESTS OF NORTH CAROLINA.

BY W. W. ASHE.

FOREST DIVISIONS.

North Carolina can be divided topographically into three well-marked divisions:

1. THE COASTAL PLAIN REGION, or coastal division lying to the eastward and extending inland from the coast for a distance of one hundred to one hundred and fifty miles, has an aggregate area approximating 24,000 square miles. Its surface is that of a gently undulating plain of slight elevation (ten to fifty feet above sea level) and more nearly level surface eastward, and becoming more elevated (three hundred to five hundred feet) and rolling along its western border. The upland soils are sandy loams and loams, rarely stiff, moderately fine and even-grained. To the north of the Neuse river loams and loose loams are the more frequent upland soils; to the south of this river they are more sandy. In the more eastern portion of this region, in the vicinity of the coast, are numerous and extensive swamps, due either to insufficient surface drainage, or the presence beneath the surface soil of impermeable strata. Their soils are silty and clayey, and compact; or sandy and loamy, and loose; over limited areas they are peaty; where they border the larger streams, that have their head-waters beyond the coastal plain region, they are silty with a small admixture of vegetable matter.

In this region the normal annual temperature is about 61°F.; and the normal annual rainfall about fifty five inches.

2. THE PIEDMONT PLATEAU REGION, extending westward from the coastal plain, lies parallel to the Atlantic shore, and to the Blue Ridge, the eastern base of which marks the region's western border. It is an extended peneplain, one hundred and fifty to two hundred miles in width, and has an area of about 22,000 square

miles. In the east its surface is rolling, but adjacent to the larger streams, and toward the western limit, it becomes more hilly and rugged, and in places even mountainous, being penetrated by spurs from the Blue Ridge. It has an average altitude above sea-level of 850 to 900 feet, but rises at the highest peaks to a little over 3,000 feet; along its extreme eastern border it is not over 400 to 500 feet. On the uplands the soils may be described in general terms as loams, sandy in some places and clayey in others, formed by the decay of slates, gneisses, granites, and other crystalline rocks. Along the numerous streams the soil is usually a fluvial deposit: a rich dark-colored loam, containing a varying proportion of vegetable matter.

The Piedmont plateau region has an average temperature of about 58.5° or 59° F., and an annual rainfall of about fifty inches.

3. THE MOUNTAIN REGION embraces an irregular and mountainous table-land, which lies between the escarpment of the Blue Ridge on the east and the Great Smoky mountains on the west. Numerous cross-chains, separated by narrow valleys or broader river basins, connect these two mountain ranges. The region has an average altitude above sea level of about 3,500 feet, but rises (at Mt. Mitchell) to 6,711 feet. It has an area of nearly 6,000 square miles. Although the mountain slopes are often steep, the soil is usually fertile, being a loam of varying physical character but generally rich in humus, open or porous and easily cultivated.

The average temperature for the region probably approximates 50° F., varying from 57.8° F., at Hot Springs, to an estimated temperature for the summit of Mt. Mitchell of less than 38° F.;[*] the normal annual precipitation is about 57 inches.

The rainfall throughout the State is about evenly distributed through the seasons; more falls, however, in July and August, and less in October and November, than at other seasons.

There are few late spring frosts; and only occasionally are there early autumn frosts before the wood has ripened at the end of the growing season.

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[*] Climatology of North Carolina, N. C. Agr. Exp. Sta. Rept., Raleigh, 1892; p. 166.

Coinciding in general with the three topographic divisions described above are three well-marked forest divisions. That lying to the eastward will be called the *coastal plain forest region.* It includes the northern part of the great southern maritime pine belt which, more or less interrupted, but retaining its characteristic arborescent growth, extends from eastern Virginia to eastern Texas. It corresponds to the Louisianian zone of the biologists.

The second forest division will be considered as the *Piedmont forest region.* The forests of this region are typical of the hill-country of the South Atlantic and Gulf states, and corresponds to the Carolinian zone of the biologists.

The most western division will be considered as the *mountain forest region.* It forms almost the southern portion of the Appalachian forests which extend from northern Alabama to Pennsylvania and New York, and is the Appalachian life zone of the biologists. On the higher mountains, but on no peaks under 5,000 feet elevation, occur isolated groups of forests, which are referred by the biologist to a more northern zone, the Canadian ; but these forests are not important enough, or sufficiently extensive in this State, to require more than a slight description.

FORESTS OF THE COASTAL PLAIN REGION.

The forests of the coastal plain region are characterized by a dominant growth of pines* on the uplands, except over limited areas where broad-leaf evergreen trees are dominant ; and conifers of several species, associated with broad-leaf trees, many of them evergreen, on the lowlands.

The variations in the character of the forests of the coastal plain region are the result of the influences of three factors : (1) The maritime conditions, due to the proximity to the ocean and sounds, which perceptibly affect the composition of the forest only in the immediate vicinity of the coast; (2) elevation above the sea level, which is so slight as to cause evident effects only along the western limits of the region ; (3) differences in the soils, to which is largely due the distribution within the region of the economic forests. The influence of the two first factors is through the temperature and relative humidity of the locality affecting the length of the growing season, the average annual temperature, and the amount of heat, or the extremes of heat or cold.

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*Pines occurring over the larger portion of this region all have 3 leaves to the sheath.

The conjoined effects of these factors separate the forests of the coastal plain region into three parallel zones or belts: (1) The maritime forests, lying to the eastward along the coast, and under the influence of the sea; (2) the forests of the pine belt; (3) the transitional forests lying along the western border of the region.

MARITIME FORESTS.

The maritime forests, extending northeast and southwest along the entire coast-line, rise from high-water mark, cover the narrow islands, the so-called banks skirting the coast, and on the mainland extend inland for a short distance, fringing the margins of the numerous streams, bays, and inlets about as far as tidal effects occur. This area is only a few hundred square miles in extent, having a length of about two hundred and fifty miles and a breadth in this State rarely exceeding four or five.

THE SOILS OF THE MARITIME DIVISION.

The upland soils of the maritime forest belt are of sand or exceedingly loose sandy loams, in a few places calcareous or limy; being sea beaches, or the remnants of former beaches lying within the existing one, and bordering the sounds and the narrow inlets. There is scarcely a differentiation into soil and subsoil, except occasionally in the larger proportion of organic matter contained in the superficial layers. Both upper and lower layers are identical in consistency, formed of large-sized and even-grained sand, with a small proportion of lime, in the form of calcium carbonate, from the weathering and disintegration of marine shells. The land surface rises usually only a few feet above high tide, though in a few places there are altitudes of 40 feet or more. Where the soils are fine-grained they are continually moist from water suspended by capillarity; where coarser and porous, they are soon dry, superficially, even soon after rains. The surface is rolling, and in a few places there are hills with broad rounded crowns, where the force of wind and surf has lifted the loose sand high above the general level.

CONDITION OF THE FORESTS.

The forests of this maritime area are composed chiefly of broad-leaf evergreen trees: water oak, laurel oak, live oak, devilwood, mock-orange, smooth sweet bay, palmetto, yaupon and myrtle, with a single resinous species, the red cedar; while broad-leaf deciduous trees are represented chiefly by the southern lin, prickly ash,* buckthorns, planer-tree and water hickory, but these are not abundant, and are nearly confined to the alluvial soils or those richest in organic matter. The laurel oak and live oak are the most characteristic trees, being common throughout, and not being found in this State farther inland; although to the southward, following the isothermal, they occur far from the coast. Other trees which in this State are limited in their distribution to the maritime forests, are the devilwood, mock-orange, smooth sweet-bay, palmetto, planer-tree and magnolia. The water hickory, found on the banks of the larger streams, extends a few miles farther inland than most of these trees, and the same may possibly be true of the planer-tree; while the water oak, red cedar and one species of buckthorn extend to within the Piedmont plateau region.

The growth of the original forest where it is yet preserved is from 40 to 60 feet in height, the trees short-boled, the crowns large and spreading, interlaced into a dense canopy. Water oak, laurel oak, live oak, red cedar, smooth sweet bay, holly, and mock-orange, in relative abundance about in the order named, constitute from one-half to over three-fourths of the growth. Where culling has been carried on occasional loblolly pines have gained a foothold, or abundant-seeding species like yaupon, red cedar and the laurel oak have greatly multiplied.

Beginning at the Virginia line and passing to the south, there is a constant increase in the number of species present, so that while only a few species are represented beyond the Albemarle sound the number reaches a maximum in this State at and around the mouth of the Cape Fear river, where at least two species find their northern limits. This enables the maritime forests to be roughly separated into two divisions: one lying to the north of Cape Hatteras, which point may be considered to mark the division between the two; and the other to the south of this cape. In the northern division, water oak and live oak, and red cedar form nearly the entire arborescent growth; while in the southern, with these occur the laurel oak, mock-orange, and, but irregularly distributed, the palmetto, devilwood, and magnolia. The palmetto is confined to Cape Hatteras and Smith's Island, the magnolia to the coast region of Brunswick county.

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*See p. 19.

Where the soils are more moist, the growth is largely of water oak and laurel oak, holly, smooth sweet bay, and mock-orange, with occasional lins, or other kinds of oaks in addition to those named above, which form a dense upper story; beneath them are small shade-bearing trees or shrubs. The forest floor is good and the humus deep. Where the soils are drier, either from greater coarseness of the sand or from being more elevated above sea level, red cedar, live oak and prickly ash, enter more largely into the composition of the forest, the trees being smaller in size and with shorter boles. On the driest soils, the growth is restricted to scattered groves of red cedar, half shrubby forms of the live oak, thickets of plum and yaupon, and other shrubs which rapidly propagate by means of root-shoots and suckers.

Probably not over one-half of the area is wooded; the remaining portion is naked, only a small part of it being under cultivation. In places along the coastal islands, and this is particularly true to the north of Cape Hatteras, there are great stretches destitute of all tree growth, the soil being a coarse beach-sand, the surface of which rises into parallel ridges which reach a height, in places, of 70 or more feet above sea level; and this sand, being fixed by no network of plant root-fibers, and containing no binding ingredient, is constantly shifting under the impact of the winds. Some such areas were originally forest-covered, but once cleared, and the humus, which was slightly cohesive, destroyed, the constant movement of the sand before the winds, which have piled it into shifting dunes, has prevented a general growth of any kind from securing a foothold. Fishermen's houses have been destroyed by these moving dunes and their sites obliterated, and others are menaced by them. Considerable areas of forest have been destroyed by the roots of trees being deeply covered with sand or the entire forest buried, thus increasing the extent of the shifting dunes. Occasional clumps of prickly ash and devilwood, which put forth adventitious roots from the young twigs as they are partly covered by the sand, or thickets of shrubby live oak, plum, and shrubs which sucker freely, maintain themselves in some places for many years. All oaks, except the youngest, are killed by such moving dunes. Red cedar, holly, palmetto, mock-orange and myrtle, not rooting from the young wood, are quickly destroyed by the covering of sand.

A maritime dune, over two miles in length and twenty feet in height, is now moving across Smith's Island, which lies at the mouth of the Cape Fear river. Starting in the southwest part of the island, and moving to the northward, it has already destroyed the forest along the southern edge of the island.

Commercially these forests are unimportant except where they produce, on some of the islands, a limited number of red cedar posts. Their protection is worthy of consideration, however, as they act as a safeguard in preventing the formation of inlets which would impair existing water-ways.

THE FORESTS OF THE PINE BELT.

These forests extend from within a few miles of the sea coast inland to near the western limits of the coastal plain region, and embrace the greater portion of the economic forests of the region as well as cover the greater part of its area.

FOREST TREES.

The pines growing in this pine belt are the long-leaf, the loblolly, the pond and in some places the short-leaf. They are for the most part confined to the uplands, and form the dominant growth with broad-leaf trees beneath them, or occur as a pure growth. Other coniferous or resinous trees found are the cypress, white cedar, and red cedar, all of which in the original forests are confined to the lowlands. The broad-leaf trees are chiefly water oak, willow oak, Spanish oak, swamp chestnut oak, overcup and post oaks, and such smaller species of oak as upland willow oak and the black-jack oak, which, though very abundant, are at present economically of little value; sweet gum, water gum and tupelo, elms, red maple, hackberry, hickories (chiefly the white, shagbark, and bitternut), and dogwood.

The larger broad-leaf trees, with the cypress and cedars, are confined to the lowlands and better class of soils, pines superseding them on the drier or impoverished soil of the uplands.

DISTINCTIVE GROWTH.

The difference between these forests and those of the maritime division are marked: The latter are composed mostly of broad-leaf evergreen species; the former are composed largely of pines and broad-leaf deciduous trees. A few trees are common to both forests. Thus the water oak is a conspicuous tree in both; but the red cedar is infrequent or altogether wanting over the larger part of the area of the pine belt. The smooth sweet bay of the maritime belt is represented in the pine belt by the closely related sweet bay. (See p. 26.)

PHYSICAL CHARACTERISTICS OF THE PINE BELT.

The surface of this part of the coastal plain region is gently rolling, there being, particularly to the eastward, areas of large extent almost level, but along the western border, especially in Harnett, Moore and Richmond counties, it is hilly and broken. The area is nearly as great as that of the coastal plain forest region, and the altitude above the sea level is about the same as was given for that, being from 10 or 15 feet along the eastern border to 150, and even 300 feet, in Moore county, along the western border.

To the eastward, in the neighborhood of the coast, where the drainage is insufficient to remove the rainfall, there are extensive areas of lowlands or swamp, mostly forest-covered; while westward, where the fall permits more thorough drainage, the swamps are restricted to narrow borders contiguous to the streams. The entire swamp-area of the region aggregates nearly 4,600 square miles.

THE CHANGES IN THE KIND OF FOREST GROWTH.

The changes in the condition of the forest growth are due almost entirely to variations in the character of the soils: porosity, fertility, the amount of moisture contained in them, and to the distribution of the soil-moisture during the growing season. The extremes of moisture encountered are from wet, or even inundated soils throughout the growing-season, to dry soils for the greater part of the year, except immediately after a rain. In fertility the range is between compact and fine-grained "mud" alluvium, containing in abundance all the elements of plant-food, to almost pure sand; in porosity, from coarse-grained sand of great depth, to compact shallow top-soils with impermeable substrata. Some soils are almost destitute of humus, while others are constituted largely of decaying or decayed vegetable matter. Such extremes of soils are often in juxtaposition, there being no easy gradation from one to the other, so that the contrast and line of demarcation between the two, and the respective arborescent growth which they support, is sharply and distinctly defined.

The forests of the pine belt are separable into two groups: those of the uplands, on which the long-leaf and loblolly pines are the dominant trees; and those of the lowlands on which white cedar, cypress, or broad-leaf trees are the most abundant.

THE FORESTS OF THE PINE BELT UPLANDS.

Forests of pine covered, at least in their original distribution, all of the uplands, there being only a few local areas on which broad-leaf trees were not subordinate to them. To the north of the Tar river, except on the porous and highly silicious soils where pure and uninterrupted forests of long-leaf pine occurred, the original forests were composed of alternating belts of short-leaf and loblolly pines; the short-leaf pine, with a subordinate growth of broad-leaf trees, largely oaks, dominating along the crests and on the drier and more gravelly soils, as occasional trees of this species still standing now testify; while on the lower, moister, loamy soils grew the loblolly pine, forming a ruling pure growth or coordinate with broad-leaf trees. To the north of the Roanoke river the long-leaf pine probably formed only two extensive forests: one on the sandy area extending north and south through Gates county, the other on "long ridge," an elevated body of sand lying to the south of the Dismal Swamp. To the south of the Roanoke river, the areas of sandy soils with the accompanying growth of long-leaf pine were more frequent, extensive bodies occurring in Halifax, Bertie, and Edgecombe counties; while in Wayne and Nash counties, to the north of the Neuse river, began the forests of this tree, which extended with their continuity scarcely b oken except by the water courses, west to the oak uplands of the Piedmont plateau and southwestward to the Gulf of Mexico. Within this area, only adjacent to the swamps were there at the first settlement of this country more than scattered trees of the loblolly pine.

The influence of man in changing and modifying the distribution of these trees in the two hundred years that have followed has been enormous.

To the north of the Neuse river the long-leaf pine has nearly disappeared. Occasional solitary trees are still to be found among other kinds of pines, or broad leaf trees, and on the sand hills of Wayne county, and in the flats of the great Dover swamp, groups of a few trees yet occur; but their commercial value as forest trees in this section has passed away. The short-leaf pine has as thoroughly disappeared from the counties lying to the north of the Tar river as has the long-leaf; the loblolly pine with an accompanying growth of small broad-leaf trees has succeeded both.

At the present time the forest of the uplands are separable into two divisions with distinct arborescent growth:

(1.) That in which the long-leaf pine is the dominant economic tree: the long-leaf pine woodland.

(2.) That in which the loblolly pine is the dominant economic tree: the level pine woodland.

In the present aspect of the forest there is no sharp line of demarcation between the two, but a differentiation is made for simplifying their consideration, as there are large areas, particularily to the south of the Neuse river, on which the two trees occur side by side forming about equal proportions of the woods, but in such places the loblolly pine is in process of supplanting the long leaf pine, and such woodland will be considered from a sylvicultural point of view, as being more suitable for the growth and development of the loblolly than the long-leaf pine. The commercial timbers of each kind now on these lands will, however, be considered.

LONG-LEAF PINE WOODLAND.

The area on which the long-leaf pine is the dominant tree, or where it yet exists side by side with the loblolly pine, extends from near Bogue sound in Carteret county, southward along the great sand bank lying between the sounds and the swamps; from the borders of the Dover swamp northward to Enfield in Halifax county, and Nashville (within the transitional division) westward to Cary (in Wake county), Sanford (in Moore county), and the eastern edge of Montgomery county, and the southeastern corner of Anson county. To the northeastward of this area, wherever the soil was suitable, the long-leaf pine has been replaced by the loblolly; but on limited areas of sandy soils, occasional specimens of the former species yet stand, unsurrounded by other large forest trees, but showing that its fellows once tenanted the entire soil. Such areas will be fully described in considering the pine barrens.

Along the great sand hills just within the sounds, the long-leaf pine occurs in open forests of small trees, now largely removed; further inland, on the praries and hillocks in the swamps and the wet-soiled downs of the coast of Brunswick county, clumps of larger trees grow at intervals; on the loams in the basins of the Black and Northeast Cape Fear rivers, and on similiar soils in Columbus, Bladen, and Robeson counties, the long leaf and loblolly pines are found together; while northward to northern Wayne, and westward to Wake and Anson counties, it forms, where unlumbered or not destroyed, a nearly pure growth of medium-sized trees.

Leaving out of consideration the few trees disseminated through the swamps on hillocks, the long-leaf pine occurs on two classes of soils:

(1.) The sands of the pine barrens, which include the drier forest lands between the sounds and the great swamps, and the greater areas of dry sandy soils lying in the western parts of the coastal plain.

(2.) The loams of level pine woodland which are at present in most places the debatable ground between the long-leaf and loblolly pines, and are, in certain sections, largely occupied by the latter species. Such areas on which the loblolly pine is now dominant will be described in considering that tree.

In the forests on both kinds of soil dissimilar changes in their composition are in progress, the result of nearly the same factors

THE PINE BARRENS.

The largest detached areas of pine barrens are the long ridge, lying to the south of the Dismal Swamp, the areas in Gates and Green counties, the one to the north of the Neuse river in Craven county, narrow strips lying north and south in Pender and Duplin counties, a great part of New Hanover county, considerable areas in the southern part of Bladen, the middle and southern parts of Wayne and Columbus, and a narrow belt lying between the vast coastal swamps and the coast in the counties of Brunswick, Onslow, and Carteret; while a single large body extends from the northern part of Sampson, the southern and central parts of Harnett, northern and eastern portions of Bladen, and northern Robeson counties throughout Cumberland to the western sections of Moore and Richmond counties.

SOILS OF THE PINE BARRENS.

The soils are of almost pure sand, containing very little clayey ingredients; loose, coarse-grained, dry on the surface, even soon after a rain, fresh below, but becoming dry to a considerable depth, and usually with no differentiable subsoil. But in the smaller areas there is a top-soil of sand, often shallow, especially around the edges where stiffer loams form a more fertile subsoil. Geologically they are of recent date.

The distinctive arborescent growth of these lands is the long-leaf pine and several small scrub oaks; the fork-leaf black-jack oak, barren willow oak, and forms of the post oak.

CONDITION OF THE FORESTS OF THE PINE BARRENS.

Generally the pine forests of the barrens resemble a two-storied high forest, there being an upper story of this pine, about 70 or 80 feet in height, with a rather thin cover, even where uninjured by fires or unlumbered; beneath the pine an open growth of the scrub oaks from 10 to 15 feet in height, or in places nearly clear. As the cover of the pines becomes thinner, the scrub oaks beneath them become more numerous. The floor is poor, and there is but little humus; it is grassy with coarse tufts of the wire grass or broom grasses or covered with shrubs. There is no young growth of the long-leaf pine or any valuable tree.

Practically all of the pine has been tapped for its resin, crude turpentine, the amount of round-timber standing, which has not had the trunk excorticated in the process of turpentining, being less than 50,000 acres. Not only has the greater portion of the timber been so boxed for turpentine, but, after the original faces have been scarified as high as possible, and the trees allowed to rest a few years, additional boxes have been cut between the former ones. Many trees, thus weakened by the deeply cut boxes at the collar of the trunk, windfall, and the loss of timber from this cause has been enormous. The resin-covered surfaces where tapped for turpentine are highly inflammable, and fires passing over the dry herbage spread to the trees and frequently destroy them.

This description represents the forests where they are in the best condition, but it is now realized in only a few places in North Carolina.

The greater portion of the forests have been culled for many years, so that there are extensive areas thinly stocked, a few pines to each acre standing in thickets of scrub oaks; or there are large areas of abandoned turpentine orchard, aggregating probably 700,000 acres, but yet containing a small amount of timber suitable for saw logs. There are extensive areas lying within these forests from which the timber has been so thoroughly removed by fires, lumbering, and a reckless system of turpentining that the lands may be classed as waste, there being on them neither merchantable trees nor young growth of any species which will, in the course of time, yield timber. Nearly all of the waste land in the eastern counties lies in the pine barrens, the larger areas being in Wayne, Sampson, Bladen, Brunswick, Harnett, Cumberland, Moore, and Richmond counties. The entire area of waste land is about 400,000 acres.

The waste lands are due to the failure of the long-leaf pine to reproduce itself to any considerable extent in these vast areas. Their present condition has been gradually matured, and the causes which have produced it may now be seen in operation in nearly any unprotected wood of long-leaf pine, where there is no young growth of this tree. The scanty reproduction is due largely to the fires which in many places pass over the land every year consuming the dead herbage, the wire grass and the leaves of the scrub oaks, and destroying the slow-growing young pines, which by the end of the fifth year have only reached a height of 3 to 5 inches above the ground; the infrequent seeding of the old trees; the enormous destruction of the seed by hogs and fowls when there is a seed-year; the further depredations made by hogs digging up the plant to get the root. It is doubtful if the partial shade of the scrub oaks is sufficient to interfere seriously with the development of the young plant, as great as are its requirements for sunlight and warmth.

The failure of the forests of long-leaf pine to reproduce themselves naturally, except to a limited extent, on any part of the pine barrens, has already been treated of in a previous report of the Geological Survey. It is a matter of importance, as the land in its present state represents a great amount of capital lying idle which might be made productive to the owner, and give employment to labor engaged in handling or manufacturing forest products. It is absolutely essential that the demands necessary for its growth be accorded it—immunity from destruction by fires, protection against the depredations of stock, particularly hogs, both to the seed and the young plant, and protection against the encroachment of more rapid-growing pines or broad-leaf trees, on soils where such will grow.

POSSIBILITIES OF THE PINE BARRENS.

The pine barrens, on account of their impoverished soils, are incapable of sustaining a wood of a large-sized broad-leaf species. The loblolly pine seems incapable of naturally securing a foothold in these sands, as nowhere in the forest does it follow the long-leaf pine as that tree is removed; and on the limited areas of old fields where it has appeared spontaneously, it seems unable to attain a large size or perfect development, the boles being short and crowded with limbs, the crowns large and spreading, the wood in the standing tree, even the sapwood, often evincing at an early age signs of decay. These are, in fact par excellence the long-leaf pine lands. No other tree for timber use is capable of attaining even a moderate development on this soil. The least exacting of the larger forest trees of the State, both in regard to soil-moisture and fertility, it is able to secure by means of its deep-seated taproot, which often penetrates the layers of sand to a depth of ten or twelve feet, the mineral elements necessary for its development, and reach on the most barren soils a height of 50 to 70 feet and a diameter of 14 to 16 inches. On the pauperized soils of the barrens lying near the sounds, the pine is unable to become more than a middle-sized tree 50 to 60 feet in height with a diameter of about 16 inches; on the deep and poor sands of Wayne, the northern part of Bladen, and portions of Sampson counties the conditions of development are similar to or only a little better than those prevailing near the coast, and continue so to the westward through Cumberland, Harnett and Richmond counties, until in Moore and Montgomery counties the loose sands become confluent with the late drifts derived from the sandstones containing clayey particles and a loamy subsoil, where a better growth can be secured. But on many of the smaller areas of sandy soils, where the taproot of the tree is able to penetrate the sand and reach a stiffer subsoil, the tree reaches a larger size, a height of 70 to 90 feet and a diameter of 16 to 20 inches.

LEVEL PINE WOODLAND.

The surface of these lands, (also see page 161), is very nearly level, slightly rolling, or sloping toward the streams; the soils loose, or moderately compact loams, or sandy loams with somewhat firmer yellow or gray, loamy or stiff loamy subsoils; mostly fine-grained, moist or fresh but well-drained. As they become more moist and more loamy the loblolly pine occupies them, especially over the large areas to the north of the Tar river.

The larger areas on which the long-leaf pine is yet standing are in Edgecombe, Johnson and Wilson counties; the basin of the Northeast Cape Fear river from the southern part of Wayne county southward; large areas in the southern parts of Bladen and Robeson counties and smaller areas in Brunswick and Columbus Counties.

As has been stated, the long-leaf pine formerly occupied the greater portion of these lands to the exclusion of almost every other tree, but as the mature trees of this species were removed or died they have been rapidly replaced by the loblolly pine and, in most places to the north of the Neuse river, and in many places to the south, this substitution has been entirely effected.

The other trees which grow on these loams with the pines are the post oak, the Spanish oak and the black oak, and small hickories and dogwood.

CONDITION OF THE FORESTS OF THE LEVEL PINE WOODLAND.

Where pasturage has not suppressed the broad-leaf element, the forests of long-leaf pine on the moist loams also resemble a two-storied high forest. The upper story is a compact growth of pine, 100 to 125 feet in height; the the lower is of broad-leaf trees: post oak, Spanish oak, and black oak, small hickories and dogwood, reaching an average height of not more than 40 feet. In few localities is this condition now realized. The cover of pine has been broken by frequent windfalls and culling; in many places browsing cattle have suppressed the broad-leaf trees, or they have been killed by fires. The loblolly pine, resisting successfully the fires and uninjured by cattle, has colonized either by solitary specimens or more frequently by groups of a few trees which have already reached maturity, or by thickets of younger ones, wherever openings in the cover above enabled it to secure a foothold. In sections long-settled, where the long-leaf pine has been culled, and in long-abandoned turpentine orchards the loblolly has replaced a great part of the long-leaf pine. The mature loblolly pines nearly equal in height the long-leaf pine and form a part of the cover, beneath which groups of young trees of the former species can be seen in all stages of development wherever, there is sufficient light to permit their growth. Nowhere except in the limited districts protected from fire and cattle, is there any young growth of the long-leaf pine. This tree, once dominant over such an extensive area, is surely failing to reproduce itself, and it is fortunate that a tree as valuable as the loblolly pine is supplanting it on these soils. The greater part of the compact loblolly growth to the south of the Tar river has in this manner gradually extended by occupying the lands from which the progeny of its closest competitor has been thus excluded by the influence of human agencies.

To the causes which have checked the growth of the long-leaf pine on the pine barrens, fires, hogs and infrequent seeding, there must be added another agency which has aided in suppressing it on the level loamy soils—the struggle with contesting species. As the cover in the long-leaf pine growth has been broken, either by trees being removed in lumbering or windfalls, seed from the loblolly pines in the swamps and along the streams have been blown in, this pine seeding more regularly than the long-leaf, and its seedlings have taken possession, the young plant not being destroyed by hogs, and by their rapid growth soon getting too large to be easily damaged by fires. Long-leaf pines, which after a time might have succeeded in getting a start, have thus been crowded out by being overshaded by the more rapid-growing loblolly pine. Under existing conditions it is impossible for the long-leaf pine to ever again succeed naturally in forming a growth on the lands which the loblolly pine has thus possessed. The shade of the loblolly pine with that formed by the accompanying undergrowth of broad-leaf trees is too deep for the growth of the long-leaf pine seedling beneath them, even where there are long-leaf pines standing near that might produce the necessary seed.

SUPPLY AND UTILIZATION OF LONG-LEAF PINE.

The larger bodies of merchantable long-leaf pine lie in Bladen, Robeson, Cumberland, Moore, and Montgomery counties, the last being within the transitional region. There are smaller bodies in Sampson, Brunswick, Columbus, and Harnett counties. Nearly all of this has been tapped for turpentine. The total amount standing is estimated to be less than 3,000,000,000 feet, board measure, distributed so as to yield on pine lands an average cut of less than 3,000 feet, board measure, to the acre.

The greater part of the long-leaf pine timber is converted into lumber. Wilmington, the chief seat of the manufactnre of long-leaf pine lumber in North Carolina, is now supplied by rafts floated down the Northeast and Cape Fear rivers. The manufactured products go to coastwise ports and the West India Islands. The total shipments of long-leaf pine lumber from this port for 1896, amounted to about 20,000,000 feet, board measure.

The most active lumber operations in the interior are at Aberdeen, Troy Junction, and near Carthage. These mills not being on large water-courses obtain their timber by means of small railways which penetrate the unlumbered forest, and on which logs are brought in and delivered at the mills.

Logs of great length are easily handled, and a large part of the timber gotten out is of large dimensions for trestleing, framing, and other exceptional uses.

All railways passing through the long-leaf pine region use ties of this pine exclusively ; and besides, such ties are used to a considerable extent on other parts of these lines not lying within the distribution of the long-leaf pine.

An explanation of the method of extracting resin from the long-leaf pine, and the manufacture of resinous products is to be found in Bul. 5 of the N. C. Geological Survey publications, 1894.

TREATMENT REQUIRED BY THE LONG-LEAF PINE FORESTS.

On such loamy soils as are suitable for the growth of the loblolly pine, and which it now occupies in a great part, it would probably be more advantageous to secure in regeneration a pure growth of that species; or, where the loblolly has only lately begun to colonize, to offer it by protecting from fires, full facilities for securing a thick stand as the remaining long-leaf pine is removed.

The area of unlumbered long-leaf pine lands in this State is now of small extent and is the seat of active lumbering operations. The growth of pine is so open (the density in only a few places being over three-fourths of the possibility), that if protected from fire and hogs until after lumbered, there would be sufficient light for a young crop to have secured a start beneath the old pines. In localities in the transitional counties, where there is a heavy underwood of small broad-leaf trees, chiefly post oak, Spanish oak, and white oak, openings would have to be made in their cover in order to afford the young pines sufficient light for development. In many places where the pine has been regularly lumbered or culled for a great many years there is a like thick growth of small broad-leaf trees beneath the remaining pines, and here too the cover would have to be thinned in order to give the young pines the necessary light. In most places there are still sufficient mature pines standing, if left uninjured, to seed the ground after two or more seed-years, if the seedlings are protected. Where there are now no seed-bearing pines a crop would have to be artificially introduced by either sowing the seed or setting out young plants. As seed in a seed-year could be cheaply secured, and the young plants if set out would also require protection, it would undoubtedly be more economical to introduce by seeding. The first and absolute prerequisite before any attempt can be made to improve the condition of the long-leaf pine forests is entire exclusion of cattle and hogs, and complete protection from fire. Laws enforcing the confinement of live stock will in a great measure secure immunity from the first evil and will materially tend to mitigate the second, as the majority of the fires which sweep across the barrens with such destruction are purposely set to remove dried grass and herbage in the spring, and afford cattle the tender, fresh shoots of the year for pasturage.

Especially might much benefit accrue to these districts by the reenactment of special fire-laws for the pine barren districts, affixing more severe penalties for their violation; establishing for their execution an administrative corps of wardens and subordinate officers, with power to summon citizens in case of fires to assist in suppressing them, to inquire into their origin, and to bring suits in the courts against offenders and violators of the laws. The present fire-law is unsatisfactory in offering no adequate means for investigation into the origin of fires, so that it is seldom or never that offenders come within its bounds.

The long-leaf pine can be reproduced only from seed, and is adapted only for pure growth in a high forest with a rotation of from 80 to 120 or more years. As the tree reaches a smaller size and attains a less age on the highly silicious soils of the pine barrens it would be more profitable to use the longer periods of rotation, for the production of larger-sized timber, only on the better class of soils. It is more impatient of the shade than any other of the forest trees, the young seedling, even, requiring direct sunlight and enduring only a moderate shade, and the trees when once stunted by over-shading, or too much compression, never recover their normal vigor.

The group system of natural regeneration certainly seems to assure the successful starting of a new crop with a greater probability of success than any other. By this system groups of trees of considerable extent are removed at intervals through the forest, the areas from which they are removed being cut clean, and regeneration taking place by seeding from the adjoining trees. The young seedlings cannot be overshaded by the enlargement of the crowns of still-standing trees as is apt to be the case in selection cutting, and a thick stand, if the group is not of too great extent, more than two hundred to three hundred yards wide, insures sufficient lateral shade during the height-growth stage to cause the formation of clear boles. Dwarfed and defective trees passed over in lumbering may be left until after a stand is secured, as seed from them will materially aid in obtaining an even distribution of the young crop; but they should be removed as soon as regeneration is assured.

Seed for planting should be gathered in autumn, between the middle of October and the early part of November, care being taken to keep them dry until sown. If the weather is at all moist and warm, planting should take place at once. This will enable the seed to germinate and root before winter. Otherwise they should be kept dry until early spring and planted not later than the first of April.

Only slight preparation of the soil is needed for planting. All broad-leaf trees should be removed, and a plowing to destroy the turf lessens the danger of the young pines being choked by the grass. From sowings carried on at Bladenboro as experiments, it would seem to take about five pounds of seed to the acre, there being about 10,000 seed to the pound.

LOBLOLLY PINE WOODLAND.

The area in which the loblolly pine is the dominant economic tree includes the greater part of the uplands north of the Tar river; most of the area lying between the Tar and Neuse rivers, except the uplands of Edgecombe, Wilson and Nash counties which are occupied conjointly by the long-leaf and loblolly pines; the basin of the Northeast river in Duplin and Pender counties; the uplands of Jones and Lenoir counties and a great portion of the uplands of Carteret, Onslow and Brunswick counties; much of Columbus and Robeson; the southeastern corner of Richmond; the eastern part of Anson and smaller areas in Sampson and Bladen counties.

The forests of this pine are chiefly confined to the level pine woodland with loamy or stiff loamy soils as were described in the growth of the long-leaf pine in the level pine woodland (p. 156).

To the north of the Neuse river, the loblolly pine forms a pure forest over the larger portion of the area, as it also does in a large portion of the coastal counties of Carteret, Onslow and Pender, on the extensive flats of the Lumber river and its tributaries in Robeson county, and on the loose moist sands of the southeastern part of Anson county. Over the rest of the area the forests are more broken, consisting of small groves in old fields, or contain both the long-leaf and the loblolly pines.

CONDITION OF THE FORESTS.

Where unlumbered, the forests of loblolly pine are compact, with a continuous cover, the forest floor being good and with a moderately deep humus. On the best soils the trees attain a height of 90 to 100 feet, with trunks of 40 to 50 feet free from limbs. On poorer soils, especially where they have appeared spontaneously in abandoned fields, which are often on the lighter lands from the greater ease with which tilled, the trees are much smaller, not averaging over 70 or 80 feet in height. They have, however, proportionally larger diameters than taller trees and usually shorter boles, the growth, when young, having been so open that the trunks have not cleared themselves from limbs. This is due to a greater number of the trees being suppressed, more light being necessary for growth on the poorer soils. The loblolly pine generally forms an upper story of pure growth, beneath which when the pine cover is dense there is a lower story of dogwood, post oak, and other small shade-enduring trees; or when the pine cover is open, as is frequently the case, there is a slightly subordinate growth of Spanish oak, black oak, and post oak, small hickory, and sometimes black gum and other trees. There is often a considerable amount of young growth of broad-leaf shade-bearing species, post oak, dogwood, black gum, and sometimes black oak and Spanish oak, which survive for a longer or shorter time beneath the shade of the other trees, the dogwood and post oak on the best soils even reaching maturity. Young pines, however, are wanting; and on the poorer soils broad-leaf tree seedlings only stand the shade, if at all, for a short time.

Where the forests of loblolly pine have been lumbered the pine shows for a few years no signs of succeeding itself, as there are no young pine seedlings beneath the shade of the mature pines. Self-sown seed, however, from neighboring trees or from undersized ones left in lumbering, even small trees seeding with remarkable fecundity and regularity, soon produce a vigorous stand of young pines in all open places and also beneath the light shade of the broad-leaf trees which often grow beneath the mature pines. This young stand rapidly pushes upward through the thin canopy to secure the light. As the oak flats are approached, with their more compact and taller-growing broad-leaf trees, it becomes more difficult after lumbering for the loblolly pine to replace itself. The rivalry between it and the competing broad-leaf trees is closer and more in favor of the shade-bearing broad-leaf element as the cover is less broken, until, on the ever-moist margins of the loamy-soiled swamps, and particularly where alluvial, the pine forms only a small proportion of the entire growth. It attains, however, in such situations its perfection of individual development. On the other hand, as the drier soils are approached there is less struggle between the loblolly pine and the broad-leaf trees; but as soon as the porous, loose, sandy soils of the pine barrens are reached, the loblolly pine with its delicate, rather superficial root-system is unable during the seedling stage to supply by its roots the water passed off through its leaves by transpiration and it succumbs during the first season.

MERCHANTABLE LOBLOLLY PINE TIMBER.

The merchantable timber had been more largely removed in the eastern counties where the numerous waterways greatly expedited exploitation as well as facilitated shipment of the manufactured products. In the counties lying north of the Roanoke river most of the loblolly pine suitable for saw logs has been cut; only small bodies attached to farms, or situated at a distance from transportation facilities yet remain. Great quantities of timber have been cut during the past twenty years for the local mills, the largest of which are located at Elizabeth City; and even larger quantities have been exported by railways and towed in rafts to mills in the vicinity of Norfolk, Va. Timber for the mills at Elizabeth City is now obtained from the forests contiguous to the Chowan and Roanoke rivers and from the counties lying on the southern side of Albemarle sound. There are still large amounts of pine timber standing in Dare and Hyde counties. The forests of Beaufort, Washington and Martin counties have, however, been nearly exhausted. In Pitt, Edgecombe, and Green counties exploitation is well advanced in the loblolly pine forests near the railways and water courses, while the greater part of the timber has been removed from Pamlico and Carteret counties. The unlumbered pine lands of Beaufort county lie in the northeastern part of the county; those of Craven in the southwestern part. Bordering the swamps in Duplin, Onslow and Pender counties are large unlumbered areas of loblolly pine growth, chiefly where this pine has superseded the long-leaf pine; and in Brunswick, Columbus, Robeson and Bladen counties, along Brown and Green marshes and the flats of Lumber river and its tributaries, are still large quantities of merchantable timber. There are smaller bodies of timber, though scarcely more than is sufficient for local use, in Wilson, Nash, Johnson, and the eastern parts of Wake and Anson counties.

FOREST INDUSTRIES.

The loblolly pine is tapped for turpentine only to an inconsiderable extent, but the lumber industries of all of the towns to the north of the Neuse river and of most of the sea-board towns to the south of it, are entirely dependent on this pine for their logs. The chief seats of the manufacture of loblolly pine lumber are Newbern, Washington, Elizabeth City, Edenton, Plymouth and Wilmington. The annual cut of logs amounts to about 560,000,000 feet, boad measure, less than two-thirds of which is manufactured in this State.

The loblolly pine is not used for railyway ties, or sleepers of any sort placed next to the earth. Railway ties for local use are made from the post oak growing beneath the pine. The dogwood is converted into shuttle blocks. No use is made of the small red oaks and other small trees which constitute the remainder of the forest.

FOREST PROTECTION.

The loblolly pine requires little protection compared with the long-leaf pine. The seed is small and is not seriously destroyed by animals or in other ways. It falls during the late autumn and winter and sprouts during the following spring and by the end of the first season the seedlings have reached an average height of about seven inches. After that they grow at a rate of about eighteen inches a year for seven years, so that specimens four or five years old are too high to have any but the lower branches scorched by a fire consuming only the leaves and herbage. The thick bark, too, is a great protection to even small trees. Since they grow on moister soils and form a deeper shade than the long-leaf pine which prevents the growing of grass there is less danger from fires. Not being boxed or worked for turpentine the mature trees are less apt to be destroyed by fires.

Where growing on drier soils the growth of the loblolly pine is not so rapid later in life as in the early years and the scars left in the natural shedding of the limbs do not so quickly heal over, many of the trees being affected by fungus diseases which gain access through such openings.

REPRODUCTION OF LOBLOLLY PINE FORESTS.

In old fields and clearings within the area of the distribution of the loblolly pine a spontaneous growth of loblolly pine quickly appears, the light, winged seed being dispersed by the wind for a considerable distance, sometimes hundreds of yards, from the seed-bearing trees. The production of seed begins at an early age with isolated specimens, sometimes, when they are under ten years old, but later with those whose crowns do not receive full sunlight, and continues uninterrupted for a great many years. There is seldom a year when some trees in a locality do not mature cones, since the trees grow under such diverse conditions of soils and moisture. The cones, which require two seasons to develop, open and the seed are distributed during the autumn and winter after they have ripened, some remaining unopened until the succeeding spring. The seed retain their germinative power for several years, but usually germinate the first spring after falling to the ground or after being planted.

SYLVICULTURAL TREATMENT OF THE LOBLOLLY PINE.

The selection system of cutting, culling, was formerly much practiced in the loblolly pine woods when the demand was almost entirely for pieces of timber of exceptionally large dimensions for special uses. By this method of cutting the largest specimens only were removed and the smaller allowed to continue their growth uninterruped. This was before kiln dried loblolly pine lumber became a feature on the lumber market and stocks of all sizes of this pine came into general demand for lumber purposes. Now clear cutting is the rule in lumbering, though much to the detriment of the forest.

In spite of the naturally abundant reproductive powers of the loblolly pine, much can be done during and subsequent to lumbering to facilitate regeneration and secure a thick stand of young pines. With clear cuttings, frequent seed-bearing trees should be left to insure a thorough and uniform seeding of the area at as early a time as possible. It is absolutely necessary to protect recently lumbered lands from fires, as in the event of one while the ground is encumbered with the tops of the felled trees, all of the young pines will be destroyed. Cattle do but little damage to young loblolly pines.

Existing woods of compact young loblolly pines, in which the trees have reached a height of 35 to 40 feet, could probably be thinned by having the suppressed and subordinate trees removed, to the great benefit of those remaining, affording more light to the crowns and stimulating rapid enlargement of the trunks. Where dense growth is left to natural thinnings, the subordinate groups, the crowns enduring a considerable compression, will interfere for some years with the larger and more vigorous specimens which are ultimately to survive. By securing thick stands, however, during the early stages of development and thinning at the right times, chiefly when the period of most rapid height-growth has passed, the accretion secured within a given time can be considerably increased above what it would be if the wood were left to natural suppression and a prolonged struggle between trees, only a small proportion of which are ultimately to survive. At certain stages of development, however, the thick stands and the struggle between the trees to secure the light is necessary to cause the rapid pushing upward of the crowns and the formation of clean shafts.

In many places where small but vigorous-growing broad-leaf species have succeeded after lumbering in securing possession of loblolly pine lands, it will be found necessary to break their cover in order to permit the pine, unable to endure a heavy shade, to obtain a foothold. On some areas not a sufficient number of seed-bearing pines were left to thickly seed the area even in several years, during which time the broad-leaf trees thicken up to such an extent as to exclude the pine altogether. Where the pines do come up in such situation they make rapid height-growth and soon overtop the broad-leaf trees.

Such conditions as this are only encountered on the better class of soils. In such places either enough pines must be left to insure thick and immediate seeding, or the broad-leaf trees must be removed or thinned simultaneously with, or just after, the cutting of the pines. A portion of the underwood, the post oak and dogwood can be removed without any extra cost, the former being in demand for railway ties and the latter for shuttle blocks, etc. In many places where the underwood is not salable, its thinning or removal in part will be a matter of necessity in order to secure successful reproduction of the pine.

An inspection of loblolly pine lands which were closely lumbered 6 to 12 years ago fully shows that regeneration is imperfect and decidedly irregular, many places of considerable extent being entirely without a young growth of pine.

As is the case with the other pines, the loblolly can be reproduced only by means of seed. It is adapted for pure growth in a high forest with a rotation of 50 to 120 years, according to the dimensions of the timber desired, and the quality of the soils; or it can be grown on the best grades of moist or damp loams, in mixed woods with the large broad-leaf species, under a more lengthy rotation for the production of large-sized timbers.

The trees, especially when young, endure some shade, and during the early stages of development the crowns are capable of withstanding considerable compression, but if overshaded for a long time are unable, when light is afforded them, to regain their vigor. Its easy reproduction by means of the light seed renders it especially adapted to clear cuttings, when regeneration can be secured from adjoining woods. That is, it is adapted to the group.

system of natural regeneration with large-sized groups, or the strip system, with groups or strips not over three hundred to four hundred yards wide. This is the method of regeneration now roughly relied on over a large portion of the eastern counties, though the seed from under-sized and defective trees, left on the lumbered area, materially assist. To make certain of regeneration the strips cleared at one time should not have a greater width than four hundred yards.

For planting very little preparation of the soil is required. Thin woods of broad-leaf trees can have loblolly pine planted with them if their cover is sufficiently open to admit of the growth of the pine, wherever the humus is not too deep, without any more preparation of the soil than turning over the humus. Waste places that are not naturally seeded could advantageously be plowed and artificially planted. Seeding can be done in early spring, the seed being covered by harrowing with brush, but should not be covered deeper than ½ inch. The greater part, if not all, of the seed will germinate the same year in which planted, usually in about four weeks. About four pounds of seed are required to sow an acre. There are about 25,000 seed to the pound. The young plants must be carefully protected from fires.

TRANSITIONAL FORESTS.

The transitional forests, lying along the western border of the coastal plain region, are formed by the overlapping of the coniferous forest of the pine belt and the broad-leaf forests of the Piedmont plateau region, so that oaks and hickories with the long-leaf pine form the greater part of the growth. These forests are best developed in the middle and southern parts of Nash county, the eastern part of Wake, and the western part of Montgomery. To the north of Nash county, in Northampton and Halifax counties, it is only occasionally along crests covered with sandy drift that the forests are typically developed; elsewhere, on the more loamy soils, the broad-leaf element exists without the long-leaf pine, and is associated with the short-leaf and loblolly pines. In southeastern Chatham and southeastern Randolph counties the long-leaf pine also occasionally occurs along sandy or gravelly crests, but the area occupied by it is comparatively small. The transitional forest is best developed in the western part of Montgomery county, where it forms a belt three to six miles in width. The trees most abundantly associated with the long-leaf pine are the black-jack oak, post oak, Spanish oak, and white oak, and white hickory; these form a low growth, 30 to 50 feet in height, and are overtopped by the long-leaf pine, which is 60 to 90 feet in height. In some localities the pine forms as much as one-fourth of the entire growth; usually, however, much less.

The loblolly pine which is associated with the broad-leaf trees in these transitional counties, is very largely second growth.

The long-leaf pine has been extensively culled in Wake and Nash counties, and but little merchantable timber of that species remains; in Montgomery county, however, the forests are still intact.

The long-leaf pine is failing to reproduce itself in these forests for the same reasons that were given for its scanty reproduction in its competition with the loblolly pine; here, the competition is with broad-leaf species.

All the transitional forests lie within the Piedmont plateau region, the forest soils being derived for the most part from crystalline rocks, and are more fertile or at least better suited for tree growth than most of the soils in the coastal plain on which the long-leaf pine is found growing.

FORESTS OF THE LOWLANDS OF THE COASTAL PLAIN.

These forests occur on lands which are swampy or inundated during at least a part of the growing season, and are naturally separable into four divisions which differ in the character of the dominant economic growth:

(1.) In which numerous broad-leaf trees, chiefly oaks, constitute the greater portion of the growth—the oak flats.

(2.) In which gums and cypress constitute the chief growth—the gum and cypress swamps.

(3.) In which the white cedar occurs—the white cedar swamps.

(4.) In which the pond pine forms the greater portion of the growth or is the largest tree—pond pine pocosins.

OAK FLATS.

The oak flats border most of the gum and cypress swamps, lying between the gum and cypress swamps and the level pine lands. They constitute about one fourth of the swamp area, or 1,000 square miles. The soils are damp or moist usually deep loams, or more often sandy loams, generally inundated during spring, with a good humus and a fair intermixture of vegetable matter in the top-soil.

Their growth is entirely of broad-leaf trees, in places with occasional loblolly pines disseminated among them, but the white and water oaks are characteristic. Water and willow oaks skirt the flats. Swamp chestnut oak and overcup oak, Spanish oak, and occasional white oaks form a great part of the growth of the interior; with them, elms, red maple, cottonwood, and more or less sweet gum and water gum. These form an upper story 80 to 100 feet in height, and of considerable density; beneath them are many small trees, post oak, hornbeam, and haws.

Where not suppressed by browsing cattle, or the shade is not too dense, young seedlings of most of the trees are represented. All of the trees endure a light shade in youth; the willow and water oaks least, the white and overcup oaks the deepest and for the longest period. In most localities pasturage is regularly practiced, this woodland being esteemed the best grazing-ground for cattle during the spring and summer, and the young growth of tender broad-leaf species is systematically suppressed. Pine and the more vigorously sprouting and rapidly growing species and those seeding most abundantly—cottonwood, water oak and willow oak—largely replace windfalls and culled specimens. The seed of the swamp chestnut oak, overcup and white oaks are largely destroyed by hogs; the seed of the other oaks to a less extent.

There is so little undergrowth, and these woods are so damp, that fires rarely pass through the flats or do any serious damage. Much of the best white oak, the several species, and Spanish oak, has been culled for making staves or for large-sized timber—tun timber—for shipbuilding, water and willow oaks or pine having replaced them. The soils, being fertile, extensive areas have been drained and put under cultivation. Where such areas are abandoned the loblolly pine with sweet gum, and if seed-bearing trees be very near, water and willow and Spanish oaks establish themselves; the pines first and most abundantly, the others later and in less numbers. If not thoroughly drained, the oaks will in time supersede the pine or a portion of it.

Where the soil of the oak flats becomes at all peaty yellow poplar occurs, but only occasional trees among the others. It is most frequent in the series of counties facing the sounds.

In a few places in the vicinity of the coast, or near large bodies of water where the air is especially humid, there is a considerable intermixture of beech with the oaks.

In connection with the oak flats may be considered the greater part of the alluvial bottom lands bordering the larger streams that have their headwaters beyond the coastal plain region. These fluvial soils are silty, a mixture of the finest clayey and silicious particles, with a varying proportion of decomposing vegetable matter intermixed. The silt becomes finer and the soils more compact as the coast is neared. On the more elevated parts of these bottoms where the periodic overflow is neither too frequent, or the rise of the water too deep, there is a mixed growth of broad-leaf trees. Variations in the kind of trees occur according to the depth and frequency of the overflow.

Where the soils are drier the water and willow oaks, white oak and the Spanish oak with shagbark hickory form most of the woods; where wetter, ash, cottonwood, and hackberry are largely intermixed, these being replaced on the wettest soils by sweet gum, water gum and tupelo with cypress and some cottonwood and swamp ash.

The white oak and ash have been extensively culled from these swamps, and merchantable cypress has been largely removed.

These woods, when oaks predominate in them, are practically under the same conditions and require about the same system of management as will be indicated for the oak flats. The white and Spanish oak are to be favored at the expense of the other less valuable kinds of trees, which if left alone are apt to take their place. On the alluvial lands the species usually succeeding the oaks are the light-seeded sweet gum, cottonwood, sycamore, and, to a less extent, hackberry and loblolly pine.

MERCHANTABLE TIMBER ON THE OAK FLATS.

The largest areas from which the white oak has not been severely culled lie in Bladen, Onslow, Jones and Pamlico counties. They will cut to the acre from 40 to 60 cords of mixed hardwoods. Where culling of white oak has long been practiced water oaks have gradually replaced them, in a great measure at least.

These forests yield excellent white oak timber and some "red" oak (Spanish oak) of large dimensions, and suitable for milling purposes; yellow poplar and cottonwood for paper-stock; a limited amount of red maple, and large quantities of white oak railway ties.

SYLVICULTURAL TREATMENT.

The seed of such species as it is desirable to reproduce should be protected from hogs, and cattle should be excluded from all young growth, until it is too large for them to injure.

The most valuable trees occurring on the oak flats are the several species of white oak and the Spanish oak, and forest management should have for its object the increasing of the proportion of these, and preventing the water oaks and other less valuable species from supplanting them.

On large areas where indiscriminate culling has to a great extent removed the species of white oak, less valuable trees have already followed, and but little can be done in the way of natural regeneration to raise the standard. Artificial re-introduction of the white oaks is necessary. This can be accomplished by thinning the existing wood of the least desirable species or by removing decrepit specimens, and underplanting with acorns, preferably with those of the swamp chestnut oak, since in the latitude of this State that is the most vigorous-growing species and reaches the largest size on such soils. Or, the swamp chestnut oak or

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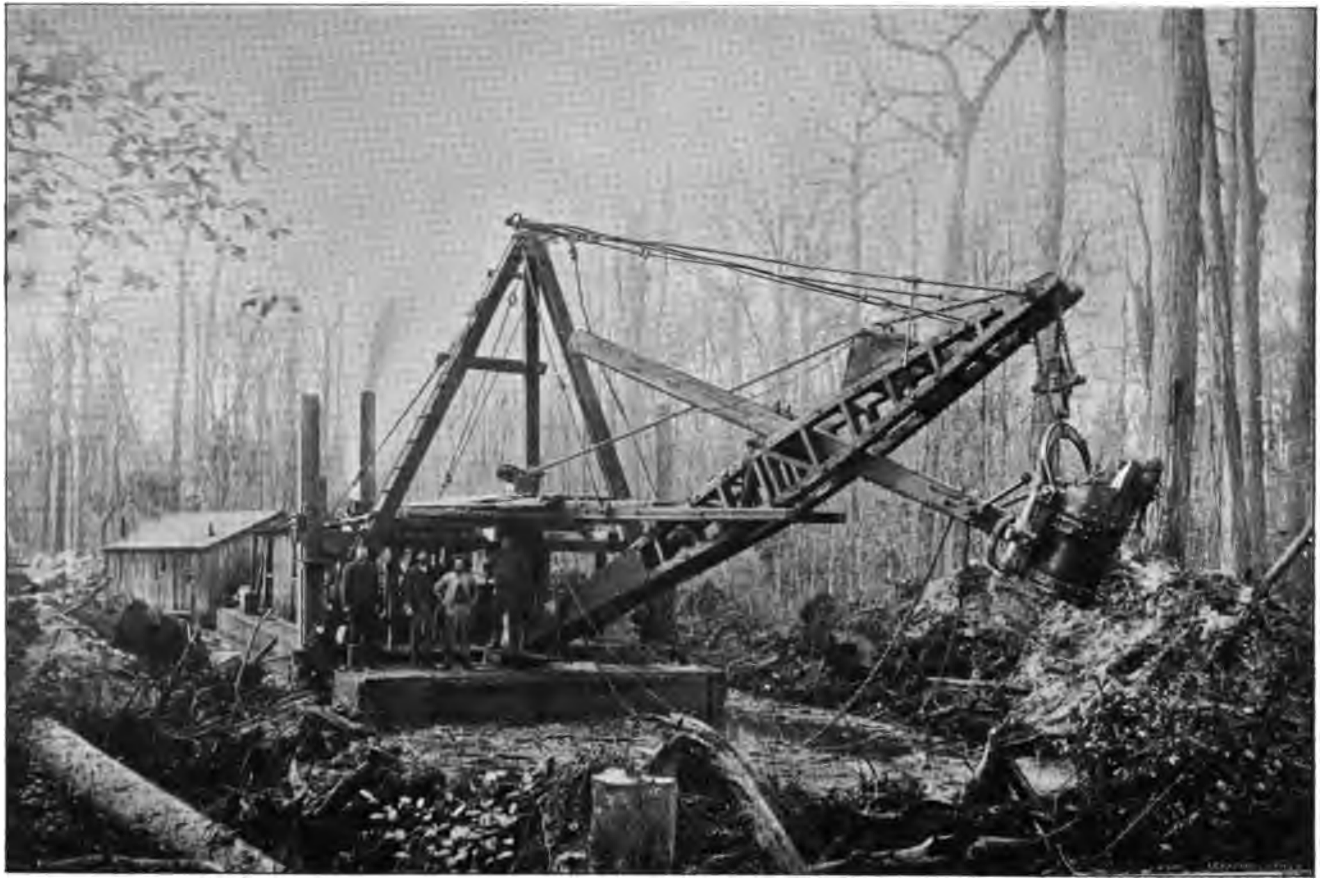

DREDGE CUTTING A LOGGING CANAL IN A CYPRESS SWAMP COLUMBUS COUNTY other desired species, can be introduced gradually beneath such breaks in the cover as are occasioned from time to time by windfalls or by culling.

If the underplanting is done by seeding, and where acorns are abundant or can be cheaply obtained this is the preferable way, being less expensive than raising young plants in nursery rows and then transplanting, the acorns should be gathered in the autumn, as soon as they have fallen; if they are to be kept for spring planting they should be deeply packed in fresh sand on the north side of a barn or some other cool situation. If the acorns of the chestnut oak are allowed to lie on the ground too long after falling, particularly if the weather is moist and warm, a great part of them will have begun to sprout and then cannot well be kept over winter. The acorns of this oak are more difficult to keep over winter than those of any other, and they retain their germinative power for the shortest time. For these reasons it may be advisable to sow in the autumn, though some of the acorns may be carried off by squirrels and mice, and there is a possibility that such as do not sprout and take root in the autumn, as most of them, however. will, may be carried off by high-water.

The oak flats and the narrow alluvial bottoms are the only lands in the coastal plain region which are capable of producing a growth of large-sized broad-leaf trees, and for this reason they assume a greater importance than their limited area would otherwise seem to justify. Whatever in the way of yellow poplar or oak timber suitable for saw-logs, or of hickory for mechanical purposes, is to be grown in the coastal plain region must come either from the oak flats or the alluvial bottoms.

THE GUM AND CYPRESS SWAMPS.

The gum and cypress occupy the deepest parts of nearly all the swamps which have a sufficiently porous soil to permit the penetration of the deeply seated cypress roots and which are not subject to drying out in the late summer; and even though the surface may be very dry in dry seasons, if the subsoil be well watered and porous, these trees may still flourish. (Plate XXI.)

They seem to be rather indifferent to the quality of the soil, attaining a large size and comparative thick growth on even the sandy soils, provided they are well watered. The presence of a deep humus which has been uninjured by fire has undoubtedly much influence.

On the sedimentary alluvial soils the growth is from 110 to 125 feet in height, and it is somewhat less on sandy soil.

The body of the wood is formed of sweet gum, water gum and tupelo, with these more or less cypress, which however seldom constitutes as much as one-fourth of the entire growth. Beneath these are small water ash, and young trees of species represented in the dominant growth, in all stages of development. The trees are all shade-enduring in their youth and, probably with the exception of the water gum, all shade-demanding in the earliest seedling stages.

It is not often that fires do damage to these swamps, as through the winter and spring they are too wet to burn; but sometimes in dry autumns the underwood is destroyed with great loss.

The injury inflicted by browsing cattle is slight.

MERCHANTABLE TIMBER OF GUM AND CYPRESS SWAMPS.

The supply of cypress suitable for making either board or shingles is nearly exhausted. In the Pamlico peninsula several large bodies are yet intact; scattered trees still stand along most of the larger streams: Roanoke, Tar, Neuse, Northeast and Cape Fear rivers; smaller bodies are yet to be found in many of the other swamps, such as those surrounding Lake Waccamaw, Big Swamp in Bladen county, and others.

Except in the few places where the forests have been unlumbered the cover is broken and irregular from the removal of the mature cypress. The thickets of water and sweet gums growing beneath them have rapidly pushed upward to take the place of the cypress on its removal.

While the timber of the cypress is of the most excellent quality, its natural powers of reproduction are so limited and the accretion of the trees after the height-growth is made is so slow that the outlook for extensive reproduction is far from encouraging.

Although the cypress does not discriminate in regard to mineral fertility of soil, it is so exacting in regard to moisture that the area which is really adapted for its best growth for timber is exceedingly limited. The trees growing on the margins of the swamps, and in swamps where the moisture is very unequally distributed through the growing season have a far larger proportion of sap than those in the deep swamps and are often seriously affected with hollows.

Although young cypress trees in all stages of development are to be seen scattered through the forests, their number, in comparison with the competing sweet and water gums is insignificant. Their height-growth, however, is rapid until the trunk begins the formation of the characteristic short, flattened, spreading crown. After the attainment of the height-growth, the diameter growth, the stage of most rapid accretion, is sufficiently rapid. The trees at this stage have a diameter of from 14 to 18 inches, and are from 80 to 100 years old, and are still largely sapwood. The diameter-growth after this becomes gradually less, until in some of the oldest and largest trees there are as many as thirty rings of annual growth to an inch of diameter. The length of time required to reproduce the forests which are now being utilized will not be less than 200 or 250 years, and many of the large trees in the existing forests are over 300 years old. For most of the purposes, too, for which the timber is used, that of the more rapid-growing white cedar is equally as well adapted. The area of such swamp land suitable for the growth of cypress is not far from 300,000 acres, while the area of gum swamp is over 1,200 square miles.

WHITE CEDAR OR JUNIPER SWAMPS.

The woodland in which the white cedar is the dominant tree occupies small shallow swamps, " bays "; or not infrequently there occur groups of a few trees disseminated through gum and cypress swamps, or more rarely in beech and yellow poplar flats where the soil and moisture-conditions become favorable for the development of the white cedar and less favorable for that of the larger broad-leaf trees.

The most extensive bodies of such swamp lie in the vicinity of the coast in the great Dismal Swamp; in the counties of Dare and Hyde; and the Pamlico peninsula, where the cedar occurs in small groups in a morass, the growth in which varies a great deal as the amount of moisture in the soil becomes greater or less. There are other large bays in Pamlico county, and on the flats surrounding and contiguous to Lake Waccamaw. Smaller bodies are scattered along the sandy bottoms of the Chowan river, and occupy small bays in Jones and Bladen counties, and the shallow flats bordering the clear-water streams, in Bladen, Cumberland, Richmond, Harnett and Moore counties. On the State's northern border white cedar occurs at an altitude of 100 feet above sea level; in Moore and Richmond counties, at twice that elevation. Its further distribution to the westward is checked by unfavorable soil-conditions. The total area of white cedar swamp does not exceed 200,000 acres.

The white cedar is confined to sandy or peaty soils. In the maritime counties it occurs chiefly on peaty soils, often underlaid by marls; in the more inland and southern counties it is found along the sandy beds of small streams or the contiguous sandy flats subject to frequent overflow; or it occupies small depressions in the sandy soils of the long-leaf pine forests forming the juniper bays. It shuns the heavy alluvial soils.

CONDITION OF UNLUMBERED WHITE CEDAR SWAMPS.

On the peaty soils of the best character, especially where lying above beds of loam or marl, white cedar is associated with yellow poplar, the gums and bays, wherever the amount of moisture and the undecomposed organic constituents become too great for the growth of the oaks. On somewhat better soils it forms dense clumps of nearly pure growth where openings occur in the cover of the dominant story of yellow poplars and gums. In the depressions in the pine barren sections in the white cedar or juniper bays it constitutes, with the white bay and the red bay, the greater portion of the growth, forming a dense wood 60 to 70 feet in height, the crowns of the trees closely interlocking above, their trunks thick, straight and slender; beneath them, and in their deep shade, are almost impenetrable thickets of young trees and shrubs. The forest floor is a thick humus or is deeply bedded in sphagnum. On the sandy flats bordering the streams, trees of white cedar occur scattered in a rather open growth of small gums and bays, and reach a height of 30 to 50 feet and a diameter of 15 to 20 inches; the humus is thin and the undergrowth thickets of small bushes.

In most localities the cedar swamps have been exploited, or the removal of the cedar is now in progress. Except where yellow poplar forms a portion of the wood, the white cedar is the only valuable tree, and it alone has been removed, all specimens usually being removed that have a greater diameter than 8 inches at the stump. Where the greater part of trees are cedar, the cutting is nearly clean, and the few small trees that are left, having very slender stems, are snapped off by the first severe storm; where there are more broad-leaf trees present, these afford protection to the young growing-stock too small to cut. The bays and gums that are left make rapid growth after lumbering, and for some time retain undisputed possession; the extremely small white cedar seedlings beneath them, although at first making slow growth in the shade, finally re-assert themselves, make rapid height-growth and break through the cover above them, and struggle with the broad-leaf species for the light. If the swamps are burned, as is frequently the case after lumbering, and the burning is not so deeply in the soil as to injure the roots of the broad-leaf trees, they will sprout vigorously from stool and root; the fire-tender white cedar, however, will be entirely destroyed, and only after a great many years will it again be introduced by wind-sown seed. If the soil is peaty, and is very deeply burned, its ability for supporting a growth of white cedar may be entirely ruined.

Only a small proportion of the area of the cedar swamps has been deforested for agricultural uses, such areas being the best drained of the peaty soils with yellow poplar as a part of the growth, and such cleared lands lie chiefly in Dare and Pamlico counties and those counties which penetrate the Dismal Swamp. Agriculturally these lands are among the most productive in the State. A few other areas may in time be drained and reduced to tillage, but most of the soil, both where peaty and sandy, is unsuited for agricultural purposes, and the permanency of the growth of white cedar on it should be accepted as an assured fact and protection and management bestowed on it accordingly.

Fires, in dry seasons, when the peaty soil or deep humus becomes thoroughly dry, sometimes spread from the pine lands, or from farms, to the white cedar swamps and inflict severe damage, destroying not only the young growth, but much of the old, and burning up the soil as well.

Extensive areas of unlumbered forests still exist in Dare and Tyrrell counties, and smaller in Gates, Jones, and Brunswick. Smaller bodies occur in Bladen, Cumberland, and Harnett counties, from which the largest specimens have been culled for telegraph and light posts.

TREATMENT OF WHITE CEDAR SWAMPS.

The white cedar is one of the most valuable trees growing in the coastal plain region. The demand for its timber, on account of its lightness and resistance to decay on exposure to moisture, is far in excess of the supply. Though exacting in regard to soil, its preferences are for such lands as are unsuited for agricultural uses. Its sylvicultural treatment is beset with no difficulties, and its rapid growth offers inducements of early returns to whoever produces it. Where culling can be practiced, and only the largest stocks removed, the largest yields of timber are secured, since the young trees which are too small for use can continue their growth uninterrupted, sheltered by specimens with firm trunks which can protect them from the wind. In only a few places, however, will economic considerations permit this, as the cost of cutting roadways, laying trams and making sound road-beds, which has to be undertaken to remove this timber, is so great that the cutting to the smallest size that can be utilized is often justifiable.

Where the soil is sufficiently wet, not so much shade is demanded by the very young plant to protect it from the sun; where drier, more shade is necessary.

As seed-bearing years are frequent, and the light, slightly winged seed are borne in abundance, modified forms of clean cutting can be carried on which will allow regeneration beneath the shade of the parent trees. After the laying out of the system of roads, a preparatory cutting can be made in which most of the larger specimens can be removed, being selected as uniformly as possible so as to distribute the light below evenly. Then two, three or four years later all of the remaining trees which can possibly be utilized can be removed, waiting though until after there has been a sufficiently large yield of seed to produce a thick stand of seedlings in the light shade caused by the breaking of the cover of old trees. The young seedlings the second year after they have sprouted will be able to endure full sunlight.

There is no doubt but that the area of white cedar growth can be much extended by introducing it artificially in localities which have a suitable soil, but have a growth of bays and large gums, which by their somewhat superior growth have naturally been able to exclude the white cedar. The proportion of it can also be increased in situations where it already grows by removing competing species,—bays and gums, and permitting the cedar by natural seedings to take their place.

Artificial propagation must be by seed, and as has been suggested, must be carried on in the shade of some other tree to protect the young seedling from too rapid evaporation during the first summer and autumn while the root-system is as yet comparatively undeveloped, shallow, and insufficient to supply water as rapidly as it passed off by transpiration. The seed, which are borne in small berry-like cones, are very small and slightly winged. The cones should be gathered in the early autumn, before they have opened or fallen, and while the seed are yet in them, kept through the winter in a place where they will not dry out, and planted the next spring by sowing broadcast beneath the trees that are to serve as protection to the young plants.

THE POND PINE POCOSINS.

These, as the name implies, have the pond pine as the distinctive growth. With it are the white bay, red bay, and loblolly bay, and less frequently small black gums and loblolly pines.

During certain seasons of the year these pocosins are swamps or semi-swamps. When they occupy the summits of the divides between watersheds, as is the case with some of the largest, they are poorly drained and often wet. They include two classes: (1) Those having a primarily pauperized soil of coarse sand, or of finer sand, silty, and more compact. (2) Those having an impervious stratum of clay, silt or hard-pan underlying the top-soil and preventing percolation of the water to underground streams or its exit by subsoil drainage. The latter may have soil rich in nutritive elements though eminently unproductive. During winter and spring such soils are saturated; during summer and autumn, from inability of subsoil moisture to rise to the surface through the impervious layer, they are exceedingly dry.

The largest areas of such swamp lie in Bladen, Craven, Jones, Pamlico, Tyrrell and Washington counties; while a considerable portion of the Dismal Swamp, in the northeastern corner of the State, has a soil and growth of this character.

The forest, even in the best condition, is exceedingly open and thin, there being an irregular growth of pine 40 to 60 feet in height, the mature trees averaging about 14 inches in diameter, and a denser underwood of small white bay, red bay and loblolly bay, almost impenetrable on account of the thicket of the gall-berry, huckleberry, and species of Andromeda and similar shrubs beneath them. Where the soil is of better quality, either more fertile, or because the impenetrable substratum is deeper beneath the surface, there is more pine, often a considerable part of it being loblolly, and the underwood is less dense. Where the soil is least fertile there is least pine and a denser thicket of shrubs.

Next to the long-leaf pine the pond pine is less exacting in regard to fertility of soil than the other pines, growing, in many places, on the soils which if dry the long-leaf pine would occupy. The young plants of the pond pine will endure a considerable shade for many years. When young specimens are accidentally broken, eaten off by cattle, or top-killed by fire, they sprout freely. During dry seasons conflagrations sometimes consume the shrubby underwood, destroying much of the timber. When the pines are thus burned out, the white bay puts forth abundant suckers, forming dense thickets, and the red bay numerous shoots;

the pine, however, in time returns. Although seed-years are frequent, the crop is usually small. The cones remain attached to the limbs for a long period, often retaining the seed for several seasons. The seed retains its germinative powers for many years and may sprout the spring of the first or second season after falling to the ground. As the trees do not grow in thick stands, they fail to clear their stocks until of a large size. Through the dead branches and knot-holes many rot-causing fungi find entrance. Many large trees are unsound from this cause.

This pine produces very little merchantable timber, though if fires are kept from destroying them the yield would not only be larger but of a better quality. In a few limited districts a considerable part of the saw-logs are from this species. It is chiefly of importance on account of the large areas in the State on which it occurs as the only timber tree.

FORESTS OF THE PIEDMONT PLATEAU REGION.

The differences in the character of the forests of the Piedmont plateau region are the results of the influence of variations in the quality of the soils, and in the altitude of the surface above the sea level. The precipitation is nearly the same in all sections of the region, and there is very little difference in the relative humidity between even extreme localities within its limits; so these factors exert only unimportant influence. The variations in elevation, too, are so gradual throughout the greater part of the region as to affect only slightly the composition of the forest, except when those of extreme distances are compared; but on the southeastern border, on the abrupt rise marking the transition to this region from the coastal plain, these forests contain certain species which are representative of the latter region, the distribution of some trees extending even much further to the westward; while other species characteristic of the sylva of the higher mountains penetrate from the northwest far to the eastward, but usually occur only around the spurs of the Blue Ridge or the isolated peaks situated beyond them in the Piedmont plateau. The forests of the eastern lowlands of the Piedmont plateau contain the greater number of species that are representative of the sylva of the coastal plain.

The distribution of the economic forests, however, is determined largely by the character of the soils.

The forests of the lowlands are of relatively small extent and importance; while those of the uplands are extensive and yield nearly all the timber suitable for construction.

THE FORESTS OF THE PIEDMONT LOWLANDS.

The lowlands of the Piedmont plateau region instead of embracing broad swamps are confined to narrow borders of sedimentary origin along the streams. Their forest growth is composed entirely of broad-leaf species except in the eastern border counties, where occasional loblolly pines are found mixed with the hardwoods.

The lowland forests may be divided into (1) those in the hollows and bordering the smaller streams, where the soils are sandy loams containing a large proportion of organic constituents; and (2) those contiguous to the larger and more slowly flowing streams, which are bordered by flats having silty soils, containing more clayey ingredients and less vegetable matter than those of the bottoms of the smaller streams. These two classes of forests and soils, sharply defined where a small stream flows into a large one, gradually pass the one into the other in ascending the rivers.

The changes in the character of the growth along the larger streams take place gradually as the changes in the composition of the soils, there being usually, no abrupt transition in the kind of growth of different portions of the some swamp, as occurs in the swamps of the coastal plain region. Many species, abundant along the lower edge of the region, the southeastern, become less frequent as the streams are ascended; others, less common to the eastward, increase in number as the soils become more loamy and the Blue Ridge is approached.

The loamy alluvial lands contiguous to the smaller streams have in all parts of the region very nearly the same kind of growth: beech, red oak, and white oak, maples and yellow poplar, while with these are associated many smaller trees: the hop hornbeam, umbrella-tree and dogwood, which sometimes are sufficiently numerous beneath the deep shade of the more lofty trees to form a thin underwood. As these soils, however, become at all silty the sweet gum and black gum, overcup and swamp chestnut oaks, and other trees which are more representative of the forests along the larger streams gradually become conspicuous: supplanting first the beech and red oak, then the white oak and yellow poplar, and finally entirely taking their place.

The body of the forest on the silty or mud alluvium of the larger streams is generally formed of sweet gum and black gum, bitternut, overcup oak and swamp chestnut oak, sycamore and hackberry. Of these trees the black gum, bitternut and sycamore are uniformly distributed throughout, although nowhere abundant or forming a conspicuously large portion of the growth; they extend beyond the confines of the Piedmont plateau and enter into the composition of the forests of the mountain region. The elms, hackberry, and sweet gum, on the other hand, become smaller in size and less frequent to the westward, until on the table-land west of the Blue Ridge they become rare trees, occurring only in the basin of the French Broad river and along the larger streams to its southward. The overcup oak is found westward but little beyond the limits of the loblolly pine in Granville county, but in Anson county it makes a broad sweep to the west, and extends up the valley of the Yadkin river, as far as the eastern parts of Davie and the southern portions of Yadkin counties; while the swamp chestnut oak extends west to the Broad river in Cleveland county and north to Granville and Davie. To the eastward it is the red maple which is the characteristic maple, while the sugar maple occurs with it in cooler places as the altitude increases, extending down to about 500 feet above the sea level. With these trees in the eastern border counties occurs the loblolly pine; and very often as far to the west as Lincoln county the water and willow oaks are found; less frequently the Texas red oak, and in a few places the big shagbark hickory. On the extensive flats of the Neuse and its tributaries, and on other streams in this portion of the State, though to a less extent, the shagbark hickory becomes one of the most conspicuous and abundant trees, while with it in a few localities is found the small shagbark.

Beneath the taller trees, no matter what kind, especially where the cover is somewhat open, are the hornbeam with the thorns and haws, and often papaw.

To the eastward a few broad flats occur, the soils of which remain moist or even wet, but are rarely inundated, and these are covered with a growth of water oak, overcup oak and willow oak, and fringed with white and black oaks. The broad flats of Little river in Union, Stanly and Anson counties, and those along some other streams in the same section of the State, are of this description.

All open banks where there is full sunlight are lined with river birch and black willow; and some flats which are subject to frequent and periodic overflow are covered with compact groves of willow or birch; or if the inundation is more prolonged, and this is particularly apt to be the case eastward, with thickets of small ash and elm.

Besides these lowlands may be added the mud or clay deposits in depressions on the crests of ridges, usually found in sections where the soils are shallow, often where slates are the country rock. They are very wet during rainy weather, and for some time afterwards, as there is little subsoil drainage; but during the summer and autumn become exceedingly dry. The growth on such deposits is usually entirely of willow oak, black-jack oak and more or less post oak.

Many of these bottoms with a loamy soil, particularly where the growth was the white oak and poplar, representing some of the most fertile land, have been cleared. Some, however, after being cleared, have been found untenable on account of the overflowing, and have been finally abandoned. Such lands are usually covered quickly by heavy thickets of birch, sycamore and elm, while maples and gums, whose seedlings grow well in a shade, soon appear beneath them.

Where lumbering has been going on along these bottoms or staves gotten out, the débris, which is carried off by the streams, often collects at shallow points so as to block the channel of the stream, and back the water for some distance above, killing most of the mature trees which may be on the adjoining bottom, as well as a greater part of the young growth, by flooding their roots. Dense and fast-growing thickets of elm and ash, and rarely black gum, appear in such places, and continue unmixed until the bed of the swamp is sufficiently raised to allow other trees to grow.

The oaks on all of these bottoms show very little young growth, if the water oak to the eastward and the swamp chestnut oak in some localities be excepted. Where oaks and other trees have been culled, chiefly maples and sweet gums have taken their places, so that the promise of the bottom lands for the future is not bountiful, nor do they now contain any large supply of merchantable timber.

IMPROVEMENT OF THE FORESTS OF THE LOWLANDS.

The forests of the bottom lands have in nearly every instance been excessively damaged by constant pasturage. The white oaks have in consequence not reproduced as abundantly as other species whose foliage and seed are not so largely interfered with by stock. To the eastward and along the stiffer-soiled bottoms the overcup oak and swamp chestnut oak are the most worthy of extensive reproduction ; to the westward and along the smaller streams where the soils are more loamy the white oak is more desirable. Protection must be accorded these in same way as was indicated in the case of the oak flats of the coastal plain region, and regeneration should be secured in the same way.

Abandoned fields and closely culled spaces on the wetter soils of the bottom lands are quickly sown in a mixed growth of light-seeded trees, chiefly birches, willows and sycamore, and among them soon appear ash and elms and other species demanding a light shade.

Sometimes, especially along fence rows, black walnuts appear, and these are worthy of protection. In open or thin places in the woods, on the drier bottoms, this tree could well be extensively introduced artificially. In the western and northern part of the Piedmont plateau it will reach a large size, but as with other broad leaf trees, it must be kept in a thick stand until the height growth has been nearly completed to secure clean stems.

FORESTS OF THE PIEDMONT UPLANDS.

The upland forests of the Piedmont plateau region are of broad-leaf species and pine, or of belts of broad-leaf trees with pine alternating with belts of broad-leaf trees without pine, there being no areas in the original forest, if some shallow granitic soils be possible exceptions, which produce a pure growth of either a broad-leaf or coniferous tree.

The sequence of belts, with and without pine, continues unchanged in this State to the northwestward as far as the eastern boundary of the mountain region in Surry, Wilkes, Caldwell, and Burke counties; and to the southwest, crossing the Blue Ridge, and with the difference between the pine and no-pine belts more accentuated from the effect of elevation, occurs to northern Georgia and eastern Tennessee.

This succession of forest belts, or the presence or absence of pine in the woods, depends on the variations in the character of the soil, as to texture, as well as in mineral constituents, and drainage. The belts of soil, following or coinciding with the geological terraines, lie, in general, northeast and southwest courses, though the interposition of dykes, particularly granite dykes, to the eastward, has produced more limited belts lying at various angles to these; and not infrequently this occurs when the order of the rock strata has been interrupted by the mere change in the direction of the outcrop. While in the original forest the areas of dissimilar growth are coextensive with certain classes of soils, and the same is more or less true of the aftergrowth in culled and coppiced woodland, in the great body of second growth seedling woods the effects of these differences in soil are largely obscured or altogether lost.

The most radical change which is taking place in the great body of the woodland is the change of growth from pine and mixed hardwoods to pure pine, by abandoned fields being seeded in pine, the place of these fields being supplied for agricultural purposes by farther encroachment on the hardwood areas. But where the relative proportion of the pure pine growth is already large, it is more desirable to reclear these old fields, on account of the ease with which these pine lands are made tillable, from the great absence of lateral roots in the pine growth and the quickness with which the stumps and roots decay in the sap trees, if cut in the spring when the beetles attack them, and the presence of the sap invites fungus diseases.

The body of the upland forest is composed of oaks with more or less hickory, and in places with short-leaf pine scattered among them. Other trees of industrial importance enter but slightly into their composition. This is the composition of the original forests as they now stand. The second growth, on the other hand, which in local cases is an exceedingly important element in the woodland, has pine for the forest body generally, and hardwoods as subordinate.

SOILS OF THE PIEDMONT UPLANDS.

The soils of these counties, unlike those of the coastal plain region, are very largely primary; or at least are not secondary in the sense of the transported drifts of the sands and loams of the uplands and the alluvial deposits of the lowlands of the east, but are derived from the decay of rock or rock forming material *in situ*. This material generally forms the subsoil, which is covered superficially, to a depth of three to eighteen inches, by a top-soil, differentiated by natural elutriation of the finer, more adhesive or clayey parts, so as to be coarser in texture and not so stiff or brightly colored as the subsoil. This top-soil, unless its depth is ten inches or over, has very little influence on the kind of tree growth.

GENERAL CONDITION OF THE FOREST.

The woodland presents a general view of wide stretches of forest of broad-leaf trees, usually with irregular and broken cover, in places much culled, and with no undergrowth where pastured, and young pines or cedar appearing at intervals through them. This broad-leaf woodland alternates with small groves of pine, usually rather open or thinly stocked, the pine being the short-leaf and scrub pine; or sometimes red cedar replaces it, or there are mixtures of these trees. The groves of pine or cedar are a young growth which has spontaneously appeared in abandoned fields. In the neighborhood of the towns the groves of pine are of greater extent, and the younger groves which are appearing are more compact, the older trees furnishing abundant seed; the broad-leaf wood is more restricted in extent and often largely formed of coppice shoots, among which many seedling pines appear when old pines are within seeding distance.

The original forest lands may be separated into three parallel belts, neglecting for the present the numerous local variations: (1) a more eastern with soils from slates, sandstone and gneiss and forests with a large proportion of pine, the *eastern pine belt of the Piedmont plateau*; (2) a middle belt with deep loamy soils mostly from granitic rocks and supporting hardwood forests of the first quality, with only small percentage of pine or none, the *broad-leaf forest belt of the Piedmont plateau:* and (3) the extensive areas of gneissic soils to the westward with smaller-sized hardwoods and more pine, the *western pine belt of the Piedmont plateau.*

THE EASTERN PINE BELT OF THE PIEDMONT PLATEAU.

The forest belt lying to the eastward with the woods composed of broad-leaf trees and pine can be separated into three divisions which differ essentially in the proportion of pine in their composition and the ability of the soil to sustain a hardwood growth of broad-leaf trees. There is:

(1) A more easterly division in extent nearly coinciding with the geological terraine of gneisses and granites, the forests of which are formed of both the loblolly and short-leaf pines with medium-sized broad-leaf trees. This is described under the name of the *forests of the eastern granite areas.*

(2) A division abutting the above on the west, and nearly including the Jura-triassic red sandstone formation of the geologists, the original forests of which contain a large proportion of short-leaf pine, with small-sized broad-leaf trees, and a large extent

of young pine, both the short-leaf and loblolly, in pure growth, *forests of the eastern red sandstone.*

(3) A southeastern division with soils from slates, for the most part rather shallow, supporting forests of short-leaf pine and small broad-leaf trees, with only a small area of young pine in pure growth. This will be called the *forests of the slates.* This does not include the entire eastern slate area, but chiefly that in the more southeastern counties* of that belt, the general limits of which will be given in describing this head.

Such differentiation, it must be understood, is merely for the simplicification of description; further division might well be made, but these show fairly well, being natural divisions, the most evident differences existing in the forests and the intimate relation existing between them and the soils.

THE FORESTS OF THE EASTERN GRANITE AREAS.

The northeastern counties of the Piedmont plateau region, Franklin, Warren, Vance, and the northern and central parts of Wake, with rolling surface, have generally grayish and loose top-soils, frequently gravelly, especially along ridges, from the detritus from numerous quartz veins, and red or reddish subsoils, deep, fresh or moist along hillsides, but often coarse-grained and porous.

The body of the forests is formed of post oak, black oak, white oak and Spanish oak, with a considerable intermixture of white, small-nut and pignut hickories, and, in most places, short-leaf pine. The larger forest pines have, however, been largely removed. Along the hollows and cooler slopes, mixed with the white and black oaks, are the northern red oak and yellow poplar, yielding a low grade of lumber, red maple and some ash; along the drier crests there is more post oak and often an increasing proportion of black-jack oak.

The woods around many of the towns, periodically cut over or heavily culled for fuel, are rapidly deteriorating into mere post oak and black-jack oak coppice, with, if fires are excluded and there are seed-bearing pines near by, an ever-increasing proportion of the short-leaf pine.

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* Largely the Monroe slates. See Bull. 3, N. C. Geological Survey, 1896, p. 36.

While the greater portion of the original growth of short-leaf pine has been removed, there are now large areas of wood, either in a pure stand of short-leaf pine, or that species mixed with the loblolly pine, especially on the lower or moister lands; and these areas contain a considerable amount of merchantable timber, though usually of a small size and yielding only sap lumber. The re-growth pine is usually at its best when growing on hillsides in culled woods with white and black oaks, where rapid development is secured, and tall and straight stocks formed. That which has colonized old fields and there formed a pure growth is straight-stemmed if the stand is sufficiently thick; but the fields, first taken in thick sod of tall grasses, are usually burnt many times while the trees are yet small, and the growth, being thus kept thin, continues as it matures open and scrubby, while the trees have short boles. Below the pine, post oak and small hickories (especially white hickory) appear, and where the soil is at all moist or stiff the dogwood spreads.

The loblolly pine when in this re-growth, here and as far westward as its distribution extends, does not do well after passing into the pole-stage, if it is growing on dry, sandy or gravelly uplands; either it spreads out, and becomes short-stocked and limby, if an abundance of light is afforded, or, if that be denied, soon dies out.

Although the woods of these eastern granite areas have long been culled, they are still yielding much merchantable building material, besides fencing-timber, railway ties (chiefly from the post oak and white oak) and large amounts of fuel, both of pine and hardwoods.

A considerable quantity of yellow poplar and some ash is exported from these areas for the manufacture of pulp, while one local paper mill employs ash for this use.

There are several small mills sawing the second growth short-leaf pine, and a few sawing the original growth.

TREATMENT REQUIRED BY THE FORESTS OF THE EASTERN GRANITE AREAS.

These forests are in most places capable of producing oak timber of considerable size, except along the summits of the hills, where the dry and coarse graveily soils are more suited for pine than the larger and more exacting broad-leaf trees. Cattle have for a number of years been excluded from the greatest portion of the woodland in a considerable part of this area, and the beneficial effects of this is evident in the thicker undergrowth. The black oaks, particularly the black-jack and the Spanish, are generally increasing more rapidly than the white oak, and do not seem to be dying out so rapidly as in counties farther west.

The very large areas of loblolly pine growth in old fields should be favored when it is on moist soils or loose loams: but on all stiffer or drier soils that of the short-leaf pine should be favored. Thinnings might advantageously be carried out for each of these species, as will be described further on.

Along all gravelly ridges mature seed-bearing pines should be preserved as seed-trees, and the proportion of pine in the small oak growth on the crests increased; on the more fertile soils of the slopes and along the borders of the hollows the pines reach their largest size, but the competition there with the broad-leaf trees is such that it is only occasionally that a pine can succeed in reaching maturity if it spring up among the broad-leaf trees.

FORESTS OF THE EASTERN RED SANDSTONE BELT.

Contiguous on the southwest to the granite areas in Granville and Wake counties just described, and extending southward through Durham, the eastern parts of Chatham, Montgomery and Anson counties, are the sandy loams yielded by the Jura-trias red and brown sandstones. This belt or terrain varies from 8 to 16 miles in width, and though its surface is generally undulating it is broken and rugged only in the few places where sandstone ridges occur, as in portions of Chatham, Moore, and the southern part Anson counties.

The soils vary from loose coarse-grained sandy loams to stiff fine-textured loams, the latter being generally confined to river bottoms. They are usually brown or gray in color, with characteristic brown, purplish, or terra-cotta-colored, stiffer subsoils; usually deep, but in spite of their depth ill-suited for tree growth.

Under denudation they wash badly, and all the finer and more silty soils bake in drying.

On the flatter lands the forests are formed of small-sized trees. In the original growth there is usually an upper dominant story of short-leaf pine from 50 to 70 feet in height, with an underwood of post oak, Spanish oak, black-jack oak, white oak, and white hickory. This often merges into post oak and black jack oak flats; or where the soil is stiffer and the country more rugged better oaks are to be found along the slopes and in the hollows. The original growth has been largely removed. (Plate XXII.)

In the southern portion of Granville, the southwestern part of Wake, and Durham, and the eastern part of Chatham counties are large areas of abandoned agricultural lands under cover of the short-leaf and loblolly pines. The pine may be seen in all stages of development, though in one grove all trees are about the same size. The loblolly is for the most part confined to the lower or flatter lands, the short-leaf to the better-drained soils and those situated at a distance from large streams where there are the seed-bearing trees of the loblolly pine. In many places the two pines occur mixed; but the loblolly generally displaces the short-leaf, growing more rapidly and enduring greater lateral compression and shade than the latter. On the driest soils, however, the short-leaf finally outgrows the loblolly and prevails. Much of this pine is of good stand and has tall and straight bodies free from limbs, and this is more true of the loblolly pine groves than of those of the short-leaf; but much more of it has been thinned by repeated fires, and is capable of yielding but little wood except for fuel. The floor is generally covered with a thick sod of broom-grass. Only a few broad-leaf trees appear spontaneously beneath these pines; those which do occur are chiefly post oak, white hickory and dogwood.

In Anson county there remains but little of the original forest. North of Wadesboro the soil is a gray, sandy loam, rolling and moist, covered with a generally compact growth of the loblolly pine, which is of fairly uniform size; high poles or small-sized mill-timber, where large tracts of cotton lands were simultaneously abandoned in the period between 1861 and 1868, and have not

MIXED PINE AND HARDWOOD FOREST OF THE PIEDMONT PLATEAU REGION

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since been re-cleared. Beneath this loblolly pine there is very little hardwood growth. South of Wadesboro the topography is more rugged, and the soils are stiffer, and along the crests and upper slopes often shallow. Everywhere it has been badly eroded. The short-leaf pine holds possession of the large extent of old fields, with, in some places, a small proportion of loblolly pine intermixed. The growth is open and stunted and in many localities dying out. There is little underwood and a consequently poor floor. To the eastward along the Pee Dee river, lie the light loams of the long-leaf pine belt, on which at the present time in Anson county, there are not over 3,000 acres of good standing pine. The remainder of the long-leaf pine lands in this county, as has been said, are covered, where the soils are dry, with small broad-leaf trees, chiefly post oak and black-jack oak ; or where the soils are moist with an open, spreading growth of the loblolly pine.

The greater part of the woodland of these counties, possibly as much as two-thirds of it, is in young groves of pure pine. The so-called "forest" pine has been nearly removed ; some is yet held in a few places. There are considerable areas of small-sized short-leaf and loblolly pine timber suitable for milling purposes, making sap lumber. Only a little of it has been cut, that chiefly for making tobacco tierces. From the broad-leaf trees (the white and post oaks mainly) hoops and staves and railway ties are made. Some dogwood is gotten out for shuttle-blocks. There are few wood-working industries, and these are chiefly saw mills, supplying in part the local demand.

IMPROVEMENT OF THE FORESTS OF THE SANDSTONE BELT.

The moister soils are capable of producing loblolly pine suitable for saw-logs, and medium-sized white and Spanish oaks. The drier soils can grow rather small-sized trees of the short-leaf pine, post oak and small-sized white oak.

Protection from fires is needed ; browsing cattle do only slight damage, except where there is a very large proportion of broad-leaf trees. All young short-leaf pine appearing in lumbered woods should be protected.

The thick groves, particularly those of the loblolly pine, might well be thinned. Very lightly at first, if the stand is very thick, and the thinning repeated after several years. If the stand is not so thick a correspondingly light cutting will be required. Seeding pines should be left around every cultivated field which in time may be abandoned, so that when cultivation ceases it may quickly be seeded in self-sown pine seed, and the young pines serve as a protection to prevent the washing away of the soil as so much of it is now destroyed.

The loblolly pine can be grown in a pure forest on all the moister soils of this division. The short-leaf pine does well in a pure growth on the better soils. On the poorer soils all the groves of untended trees now have too open a stand. This may be due entirely to external influences; in many places it is evidently traceable to fires. If this be due in certain cases to the natural thinning out of the pine on such soils as the trees become of large size, in all such cases underplanting will have to be resorted to.

FORESTS OF THE SLATE SOILS.

The geological formation of crystalline schists and slates, which extends from Person county southwestward to Union, yields two extreme types of soils, each supporting characteristic growth. The first of these to be here described is the less suited for the growth of trees, and has woods of pine and small broad-leaf trees; the second produces woods of broad-leaf trees of a larger class and no pine, and will be described further on in considering the belt of red and gray loams which lies next to the west.

The first soil referred to as being a characteristic one over a large part of these counties is a usually shallow, close and stiff, yellow loam, sometimes superficially sandy, derived from gray or yellow slates, and is nearly confined to the southern counties: Randolph, Stanly, Montgomery, and Union. The topography of the districts where such soil is found is simple, the surface nearly flat or gently rolling. Throughout it is ill-drained, and the variation in the growth is incidental to the thoroughness of the drainage. Where better drained the forest resembles a two-storied high forest. The upper story consists of a rather open growth of short-leaf pine rising to a height of 50 to 70 feet; the lower story of small post and black-jack oaks, with more or less Spanish and white oak and white hickory, has an average height of 40 feet, individual trees acquiring a diameter of 14 to 18 inches. The trees are often shrubby, and there is very little young growth. As the soil becomes poorly drained the pine decreases, until on the "willow oak flats" the growth becomes restricted to black-jack and post oaks as a lower story, slightly overtopped by willow oaks, a growth capable of yielding only a limited number of ties, and felloe and hub-material.

In Davidson, Stanly and Union counties mines have been worked for many years, requiring large amounts of fuel and posts which have been gotten from the neighborhood. Such deforested districts are now generally covered with a coppice of good stand, often with many young pines and some seedling oaks intermixed. Along many of the river hills through here thickets of the scrub pine may be seen. It appears to be spreading eastward from the granite knobs above along the rivers, occasional trees yet being seen in culled or coppiced woodland as far to the eastward as Orange county.

There is a comparatively large part of the area of these counties in forest and only a small amount of second growth woods; and as the woods have been but little culled a correspondingly large amount of merchantable timber, pine in places and oak suitable for ties and wagon-material. These forests have in many places been badly injured by frequent and destructive fires, but during late years the woods have been better protected and the adoption of laws requiring the confinement of live stock in several of the counties has tended to diminish the evil and at the same time improve the general condition of the woodland.

The soils of the first division are on the whole too shallow to make large-sized broad-leaf trees. The most valuable tree is the short-leaf pine; next the post and white oaks and white hickory and dogwood. The pine will make medium-sized mill-logs; the oak scarcely more than railway ties and smaller material.

Fires should be rigidly excluded, as their damage to young pine is great. In most places cattle should be excluded. Improvement cuttings could be advantageously conducted throughout nearly this entire section, defective pines being removed and old black oaks and Spanish oaks that are interfering in any way with young growth of more valuable species. The proportion of pine can be largely increased in such soils as are sufficiently deep to permit its growth, the amount of post oak increased on the crests of ridges, and of white oak on the slopes and better soils.

THE DECIDUOUS FORESTS OF THE PIEDMONT PLATEAU.

Beginning in Mecklenburg county and extending northeast through Cabarrus, Rowan, Davidson, Guilford, and Caswell counties and west to the middle parts of Davie, Yadkin, and Rockingham counties are red and gray compact loams, sometimes loose, rarely sandy, derived largely from gneissic or granitic rocks; and with these may be included the loose loams of Orange, Granville, and Alamance counties, and the stiff red loams of central Iredell, middle part of Lincoln and Catawba counties, and the loose and sandy red and gray loams of southern Cleveland and Rutherford counties. This territory embraces the great body of the fertile upland soils, both stiff and loose, of the Piedmont plateau.

The forests were originally of the first quality, consisting of compact-growing hardwoods, oaks, and hickories, with pine disseminated only on rocky or sandy soils along the crests of hills. They differ from those lying to the eastward in the almost total absence of the short-leaf pine in the original forest, the rather limited area of young pine in pure growth, and the presence in many sections of the red cedar and scrub pine as the old field growth.

FORESTS OF THE COMPACT RED LOAMS OR "RED CLAYS."

The stiff red soils, the so-called "red clays," derived from hornblende-bearing rocks are fertile, and are usually free from stones. The soils are in narrow terraines, two to twelve miles wide, lying in a northeast and southwest direction, the largest extending from Charlotte to Concord, with a length of about thirty-five miles. Other extensive bodies are at Salisbury and Lexington ; several smaller are in Guilford county, and a large body extends through central Alamance and Orange counties, and the northwest part of Person county. Besides these bodies are the areas in Catawba, Lincoln, and Iredell counties already referred to, and smaller areas in other portions of these counties.

The forests of the compact red loams are composed of black and white oaks, white and small-nut hickories with small intermixture of Spanish oak, and along the crests of the ridges, of post oak; but on lower hillsides and steep north slopes the yellow poplar, northern red oak, shagbark hickory, and white ash also occur. These trees in the most favored situation form a forest whose canopy is raised 90 to 100 feet, and the trunks which support it are free from limbs for 40 to 60 feet. Beneath these trees where there has been no pasturage there is in many places a heavy undergrowth of dogwood and young trees. The wooded land is for the most part distributed among small farms, and much of it has been heavily culled of the white oak for building and fencing-material, and in places the Spanish oak has been removed for the same uses. Where such culling has been done and the woodland pastured at the same time, the growth has remained open and there is no underwood: and although in many such tracts no pasturage has been permitted for the past five or ten years, the reproductive power of the black oaks seems to be so impaired, possibly from the dry and impoverished floor, that seedlings are infrequent and small, and few young black oaks are to be found in the undergrowth now appearing, which consists of dogwood, hickories, haws, and young white oaks. There are still many fine bodies of hickory, although much has been cut from these lands for numerous local buggy and spoke factories, and much has been exported in the log.

Old fields on the compact red loams are not frequent and they are either tardily taken by pine, the seed being borne there from trees at a distance on other soils, or sometimes they are taken by thickets of sassafras, sumach or by persimmon, and in a few localities by red cedar. Sometimes, however, a growth of mixed broad-leaf trees, whose seedlings are light-bearing, appear, Spanish, post, and white oaks, white hickory, dogwood, and sourwood.

IMPROVEMENT OF THE FORESTS.

These forests are capable of yielding large-sized oak and hickory timber. The white and black oaks are the most valuable trees growing on these soils, and are better adapted to them than the others; the Spanish oak is less suited. Of the hickories the smallnut and the white make the most rapid growth and thrive better on this stiffer soil; the small-nut on the shadier slopes or where the stiffest soils prevail; the white where the soils are drier or not so stiff. The short-leaf pine will attain a large size and make exceedingly rapid growth, either in growth with other trees or when growing alone.

Browsing cattle and hogs should be excluded, and fires, which at present are of seldom occurrence, should be guarded against. Where the woods have not been pastured there is usually a heavy stand of young trees beneath the old ones, and generally of the same kind, although not by any means in the same proportion. There are great numbers of white oaks, especially four-year-old seedlings, and thickets of saplings, from the two latest heavy masts, around and beneath seed-bearing trees; and this young growth is most promising. Defective old trees, or objectionable species, black gums, scarlet oak and other trees of less value which by their shade are interfering with such young growth should be removed, and if it will pay to turn them into cord-wood they should be cut up and hauled out, as little cutting and injury being inflicted on the young growth as is possible.

There is in some places much mature timber: when it is post oak, chiefly suitable for railway ties; when white and black oaks, it will yield small-sized milling timber, and this is often standing to the great detriment of the thick young growth beneath it, and might well be partly removed to give the young growth an opportunity for development.

Where pasturage has been uninterruptedly practiced for many years and the woods are open beneath, there being no underwood of young trees, an absolute exclusion of cattle is demanded in order to secure the regeneration of a new crop beneath the old trees. Where lack of grazing lands makes woodland pasturage necessary, the plan of utilizing one-half of the woodland for grazing until the young growth in the other portion becomes too large to be injured by cattle, and then turning the cattle into that, while the pastured area is permitted to rest and secure a new growth, could be adopted. Where there are yet many black oaks, white oaks and hickories standing, they can be allowed to naturally seed the ground, and the seedlings from them form the new wood.

In places, however, these species are nearly wanting, or the white oak has been largely removed, so that if a new crop were to be naturally regenerated beneath the remaining trees it would be formed largely of little-desired species. Underplanting with the white oak, and retaining the old cover for several years, and then removing it after the young white oaks have formed thickets so as to shade the ground, is here recommended. The most naked spaces, without any cover at all, might well be sown in the short-leaf pine.

Some localities show absolutely no signs of young growth of broad-leaf trees except such kinds as are neglected by browsing cattle; the old trees which are standing have passed their maturity, their tops are decaying, the trunks are often hollow, and their vigor is constantly lessening from the free access of the sun to the soil around their roots. Any kind of a young growth in such situations will be valuable in protecting the soil from washing and preventing the further decay of the old trees by shading their roots. Nearly all of this thinned wood has more or less young short-leaf pine in it which is rapidly increasing, being passed over by cattle.

THE FORESTS OF THE LOOSE GRAY LOAMS.

The forests of this division cover the greater portion of the section of the Piedmont plateau which lies between Rutherford and the southeastern part of Mecklenburg, on the south and west, and Yadkin, Rowan, Caswell and Orange counties on the north and east; within this division lie the smaller areas of compact red loams with their somewhat different growth. There is not always a sharply defined limit between the loose gray loams and the compact red loams, one gradually passing into the other; more often the areas of compact red loams have sharply defined limits. The more sandy soils prevail, however, in Alamance, Orange, the western portion of Chatham and in Person counties, in the southern portion of Mecklenburg, and the southern parts of Cleveland and Rutherford counties.

The gray loams are loose, even sandy in places, with the subsoils stiffer and bright-colored, deep, well drained, but fresh or moist and well suited for tree growth. In a few places they are rocky or even bouldery as in portions of Orange and Alamance counties.

In general, the forests are quite similar to those of the compact red loams; but the Spanish oak to a large extent replaces the black oak; there is more post oak, and the standard of excellence is not so high.

The composition of the original forest may be said to be of white oak, Spanish oak, post oak, black oak, white hickory, and scarlet oak, in relative abundance about in the order named, and forming over three-fourths of the growth; beneath these trees is a selection of underwood, where it has not been suppressed by pasturage, which shows a fair representation of the dominant trees, and with these the dogwood, sourwood, haws, and thorns. Dogwood, however, is not so abundant as on the compact red loams. On slopes facing the north and cool hillsides there is but little ash and red maple, and only occasional trees of the northern red oak, but yellow poplar is more frequent.

Pine, though infrequent on the stiffer soils and confined to the ridges, forms on the looser a not inconsiderable element in the woodland, from ½ to 2 per cent. of the mature trees often being pine, these being large and tall, but scarcely overtopping the hardwoods.

Where the soil is poor and sandy as in southern Mecklenburg, there is a reoccurrence of the pine, post oak, and black-jack oak growth, with the pine as an upper story and the broad-leaf trees as a lower. The area of such sandy land, however, is limited, and it is generally largely cleared for cotton culture, with the greater part of the woodland hardwood coppice and pine regrowth.

To the eastward in Person, Orange and Alamance counties the small shagbark hickory is frequent along the crests of sandy ridges, forming in a few places as much as 10 per cent. of the growth over limited areas.

Where high hills occur with sandy or gravelly crests, and especially if bouldery, as the river-hills along the Deep and Haw, and the elevated ridges in Person county which centre around Fuller mountain, the chestnut oak becomes conspicuous, and in culled and coppiced woodland rapidly propagates, seeding at an early age, and abundantly reproducing from stool shoots.

Coppiced and culled woods deteriorate in two directions according to the kind of soil on which they grow; if on sandy soils the early seeding black-jack oak and post oak increase, their seedlings, appearing among the stool shoots, the trees of these species becoming large enough to produce seed before those other kinds; on the stiffer red soils where the black-jack oak is wanting, the sourwood increases rapidly for the same reason, it seeding at a very early age, especially from shoots.

On the hillsides in culled woods many maple seedlings occur, and reach a height of 20 or 30 feet, and then die. The black gum does the same, small trees of this species often forming a considerable proportion of the young growth; but although it reaches a much larger size than the red maple, and persists for a far longer time, it, too, is finally suppressed by more rapid-growing trees which are better suited for the dry soils. To a less extent the same is true of the sweet gum, but unless in rather favored localities its seedlings, which appear in many places in the woods, die after a few years growth.

Where the soils are not too sandy or thin there is a growth of broad-leaf trees nearly as excellent in quality as that on the compact red loams. Its average height, however, will scarcely exceed 85 feet, and as the soil becomes more silicious there are fewer small-nut and shagbark hickories and black oaks, these being supplanted by post and Spanish oaks; or, if the country is rugged and the crests of the hills rocky and gravelly, especially if with quartz fragments, the scarlet oaks and pignut hickories enter largely.

These forests require the same management and care for their improvement, as was indicated for those of the compact red loams.

GENERAL CONDITION OF THE DECIDUOUS FORESTS OF THE PIEDMONT PLATEAU REGION.

Between 80,000 and 100,000 acres of oak and hickory woodland situated in Person, Caswell, and Granville counties were burned in the spring of 1893. The greater portion of the mature and large-sized oak and hickory timber was killed; and while the tops of all smaller trees were destroyed, they put forth abundant stool shoots so that the burnt areas are now covered with thickets of young sprouts. There is another large burnt area in the north-eastern portion of Rockingham county over which a fire passed about 1875. This is now covered with a thick growth of small trees about twenty years old, there often being several stocks from the same stool so that they interfere with each other and prevent development.

While at the present time, on account of the general distribution of groves of seed-bearing short leaf pine, this species quickly forms a stand in abandoned fields, as is the case from Rutherford, Cleveland, and Mecklenburg counties north to Davie and Guilford, yet in many portions of southern Alamance, the northern parts of Orange, in Person, Caswell, and the eastern parts of Rockingham and Forsyth counties, the short-leaf pine does not rapidly take old fields, from five to ten years or even more being required for a thick stand to be naturally secured.

In the eastern portion of Guilford county, and in Alamance, Orange, Person, and Forsyth there is a large proportion of red cedar associated with the short-leaf pine, in localities where the pine does occur in the old field growth; but the cedar is finally suppressed by overshading. In some localities cedar unmixed with other trees forms the regrowth. This tree is also rapidly increasing in culled woods, but, as in the pine groves, it is unable to endure the deep shade of the broad-leaf trees, being of much slower growth than they, and is at last overshaded. In the counties to the west of Guilford, and especially in those to the south-west, there is not so much red cedar.

Where neither the red cedar nor short-leaf pine appears in the old fields, as in portions of Guilford, in Caswell, especially in the valley of Country Line creek, in Rockingham and Forsyth counties, and to a less extent elsewhere, the scrub pine forms a large portion of the regrowth in old fields, in many places forming compact thickets of pure growth; in others, thickets of the short-leaf pine and scrub pine alternate. The two pines are sometimes associated. When this is the case unless the short-leaf pine has the advantage of a start of a few years growth, the scrub pine, being the more rapid grower, will overshade it and suppress it. Less frequently is the scrub pine associated with red cedar in these groves.

The scrub pine forms groves of pure growth on the granite knolls which extend across the eastern edge of Cabarrus county into Rowan, and the dissemination in the old fields has probably been from the trees on these knolls and those growing along the hills of the Haw and the Deep rivers, as the scrub pine is not found at other places in this division in the original forest.

Probably as much as one-third of the area of this division is in wood, and over one-half of the wood is regrowth. A greater portion of the regrowth, over a third at any rate, is pine and cedar. There are besides large areas of waste lands, with almost no tree growth of any kind, or exceedingly thinly stocked with pine or oak, chiefly post oak, black-jack oak, and Spanish oak stool-shoots.

There is almost nó merchantable heart-pine suitable for milling. The local bodies of regrowth pine which are now large enough for small sized saw-logs will yield only sap lumber, and are not generally utilized on this account; but there are large quantities of pine suitable for fuel. There is not very much oak, either white or red oak, which is suitable for lumber. What there is lies chiefly in Orange, Person, and Davidson counties; but there are smaller bodies in other places. Smaller white oak and post oak, suitable for railway ties, in most places is not abundant, many sections not producing enough to supply the local demand. Hickory, however, is relatively more abundant, not having been so largely culled for local use; numerous spoke and tool-handle factories are now utilizing this. There are few saw-mills, and nearly all of the building material used by the larger towns is brought from other sections of the State.

THE WESTERN PINE BELT OF THE PIEDMONT PLATEAU.

Lying to the west of the compact red and gray loams are fine-grained and mostly sandy loams, usually red or reddish in color with a thin surface soil, usually less fertile than the compact red and gray loams and less suitable for tree-growth. This division extends from the central part of Rockingham, Iredell, and the central part of Rutherford counties northward and westward to the base of the Blue Ridge and its outlying spurs. A few local areas of compact red loams occur, and the original timber on these soils was entirely of broad-leaf trees.

The surface of the entire division sloping eastward from the escarpment of the Blue Ridge is broken and rugged. The culminating points of the divides between the rivers which here find their head waters are low mountain chains running irregularly east and west. These mountains and the groups and isolated peaks, lying still further to the east, the Sauratown and Crowder mountains, and Kings mountain have an arborescent growth similar to that on the eastern slope of the Blue Ridge, and their woods will be considered in connection with that (p. 210).

Here, however, it may be well to say that the woods on the north slopes yet contain some merchantable yellow poplar in some of the hollows, with ash, northern red oak, and white oak. The woods on the southern slopes, and this is especially true of the South mountains, the Sauratown and King's mountain, and the broad water-shed between the Green and Pacolet rivers, have been many times burned, and pine timber has been very badly damaged while tie and tan-bark oak has been greatly thinned or reduced to stool-shoots.

The forests of this division are of pine mixed with broad leaf trees, of which the scarlet oak is the most abundant. It is especially common on gravelly soils and has associated with it the Spanish oak, post oak, white oak and, to a less extent, the black oak, while along all high and sandy crests and rocky slopes the chestnut oak becomes a tree of economic consideration. There is not so much hickory as in the oak forests of the central portion of the state this group being represented chiefly by the pignut, white, and some smallnut. The sourwood becomes even more conspicuous than in Davie and Guilford counties, and along the hollows and northern slopes there is some yellow poplar, ash and northern red oak.

These woods are in a far more uniform condition than those lying to the eastward and are much less broken. There are broad expanses of woods, formed of pine mixed with broad-leaf trees, with the cover entire or somewhat broken, and dotted with small groves of pure pine, either the short-leaf or the scrub, in old fields; or there are extensive areas of culled or coppiced woodland adjacent to the farms and small towns.

Throughout some portions of the division cattle have been excluded from the woodland for periods of from five to ten years, but most parts are yet pastured. The forest floor is generally poor, the underwood thin or entirely absent, and the cover of the mature trees open.

The original forest is from 70 to 80 feet in height, though in many places it will not be over 60 feet where the soils are thin and poor, while in hollows and on cool slopes many trees will measure over 100 feet in height. Considering the division as a whole, the trees stand in relative abundance about in the following order: short-leaf pine, scarlet oak, black oak, white oak, sourwood, chestnut oak, post oak, Spanish oak, and white hickory. These form considerably over three-fourths of the growth. Less abundant and forming the larger portion of the remainder of the growth are the dogwood, pignut, chestnut, black-jack oak, black gum, and small-nut hickory, scrub pine, and red maple.

The culled woods show an increased proportion of young pine; while scarlet oak, chestnut oak, and sourwood are increasing in both culled and coppice woods, the scarlet oak more rapidly than any other oak. Its young growth often forms thickets in the open spaces where trees are removed in culling; and in coppiced woodland it reproduces rapidly both by seedlings and stool-shoots. It is chiefly on the drier sandy and rocky soils that the chestnut oak is spreading most rapidly under culling, especially where the cutting is heavy or where the woods are coppiced; so that large areas where fuel is regularly cut show a growth which has deteriorated, so that while it formerly consisted of mixed oaks and hickory, now it is of scarcely other trees than the scarlet and chestnut oaks. Both of these trees, however, are well-suited for coppice-cutting on account of their rapid growth, vigorous sprouting, and the long persistence of the stools.

The increase of the red maple in culled woods is also rapid. Under the protection of the light shade so afforded maple seedlings can be found on all classes of soils from the driest to the most moist. On the moister soils they seem to be incorporated as a permanent part of the growth; but where the soils are dry they grow more slowly and are overtopped by the oaks when eight or ten inches in diameter, put up sprouts from around the base of the trunk, the main stem becomes weakened and dies. In like manner many seedlings of the yellow poplar appear; those on the drier soils soon succumb; those on the moister persist for a long time, if on a north slope even becoming large trees. Black gum seedlings, which are frequent on the drier soils, continue to grow for many years, but the specimens never become more than small-sized trees.

The regrowth in the old fields is uniformly pine, except in a few local areas of compact red loams, where it may be red cedar or scrubby broad-leaf trees as well as pine. The pine in old fields is usually the short-leaf; but in some sections it is the scrub, especially where adjacent to the mountains, or where thickets of that pine occurred in the original growth, as along steep river hills or the thin soils near granite knolls, the so-called "flat-rocks." Less frequently white pine forms the old field growth, and then only at the base of the mountains where mature trees of this species occur. Beneath pine regrowth of all kinds, unless the cover is exceedingly heavy, sourwood, red maple and dogwood appear.

MERCHANTABLE TIMBER OF WESTERN PIEDMONT PINE BELT.

The forests of the western pine belt now yield more timber than those of any other part of the Piedmont plateau region, and exploitation is not so far advanced in them as elsewhere. There are many mills sawing pine and soft woods in Wilkes and the northern part of Alexander counties; mills cutting hardwoods at Hickory, Morganton, Lenoir, Old Fort, Thermal Springs and at other localities, while mills sawing pine are scattered through the entire territory.

Several local tanneries obtain their bark supply, chiefly chestnut oak and white oak bark, from the immediate neighborhood, but they have removed only about one-half of the available amount in the South mountains, and that in the Brushy mountains and on the slopes of the Blue Ridge has yet scarcely been touched. The largest tanneries are at Morganton and Wilkesboro.

The largest areas containing merchantable pine lie in Caldwell, Burke, Alexander, Wilkes, and the northern parts of Cleveland and Rutherford counties. Some white pine of a low grade is furnished by the counties lying along the base of the Blue Ridge. It is locally used for building material, but far the greater part of the lumber manufactured is utilized in making shipping boxes for local cotton and woolen mills. The northern pitch pine occurs through here above an elevation of 1,300 feet, usually growing with the short-leaf pine and distinguished from it under the name of "black pine"; and along the mountains, above an elevation of 2,000 feet occur occasional specimens of the Table-mountain pine, which finds its eastern limits on the rocky summits of King's mountain in the southeast and the Sauratown mountains in the northeast, though in the intervening territory between these two mountains and the ridge of the Brushy and the South mountains it is not known to occur. All of these pines afford merchantable milling timber. The scrub pine is abundant on the shallow soils of the mountains and along the Blue Ridge, frequently forming small patches of unmixed growth. The milling oak timber is the white, some Spanish, red and black oak; there is a great deal of white and chestnut oak tie-timber, but not so much post oak as farther eastward, the scarlet oak largely taking its place.

IMPROVEMENT OF THE FOREST.

These forests are capable of yielding short-leaf pine, which will on the best soils attain a height of 90 feet, and on the poorer a height not exceeding 70 feet; and many of the soils, on account of their poorness, are much more suited for a growth of pine than of more exacting broad-leaf trees. The white and chestnut oaks grown on the crests of the hills will make trees large enough for railway ties and tan-bark but scarcely larger; on the moister upper slopes the black and white oaks attain sizes which make them suitable for milling-timber; on the cooler and moister lower slopes the white oak, northern red oak and yellow poplar attain moderately large dimensions and form good timber. The Spanish oak generally reaches only a small size and is often defective; and the same is true of the scarlet oak. Sourwood large enough to be of value commercially is usually defective. The white pine will certainly do fairly well in a few localities along the western limits of the division, and though at this low elevation it fails to clear the stocks, at least in the forest specimens, as it does at a higher elevation, it is worthy of being protected on account of its rapid growth. Thickets of pure growth will probably form cleaner shafts than where single specimens appear in mixed woods.

The broad-leaf trees require such care as was indicated for those of the compact red loams (p. 198). The white pine can be treated in the same way as will be given for the groves of that tree occurring in the high mountains (p. 218).

FORESTS OF THE MOUNTAIN REGION.

The differences in the character of the forests of the mountain region are not determined so largely either by the kind of soil or by the amount of moisture contained in it as are those of the Piedmont plateau and coastal region. Within short distances among the mountains there are wide variations in elevation. With increased elevation a rapid lowering of the average annual temperature takes place, and a proportional shortening in the growing-season; increase in the rain-fall and relative humidity, and a decrease in evaporation both directly from the soil and through transpiration. The effect of these factors in limiting the distribution of certain species is more evident than that of the soils; though, between certain limits of elevation, changes in the character of the soil influence the kind of growth. It is doubtful, however, if changes of soil in the larger mountain masses above 5,000 feet elevation produce any change at all in the kind of trees, the number of species being limited to those whose hardiness of crown or foliage and short growing-season render capable of withstanding the sudden changes of temperature to which they are subjected toward the summits of the higher mountains. At high elevations certain trees are to be found both along dry ridges and in cold swamps; the white and pitch pines and black gum; and, choosing less noticeable extremes of soil, are the red oak, hemlock, beech, birches, and sugar maple.

The forests of the mountain region are separable into three zones or belts lying at different elevations. These may be described as follows: (1) The forests of the lower mountains: (2) the forests of the higher mountains; (3) the forests of the mountain summits.

THE FORESTS OF THE LOWER MOUNTAINS.

The forests of the lower mountains lie between 1,500 and 3,000 feet elevation. They occupy the eastern and southern slopes of the Blue Ridge and its outlying spurs, and the minor chains of the Brushy and Sauratown mountains which penetrate or lie within the Piedmont plateau region; and to the westward of the Blue Ridge they occupy the hills and lower mountain slopes about to the maximum elevation given above.

Oaks, white, chestnut, black, scarlet, red and shingle, with some hickory, chiefly white, bitternut and rarely the shagbark and smallnut, with the chestnut and occasionally dogwood, are the chief broad-leaf trees. The pines are the short-leaf, pitch, Table mountain, scrub (Jersey) and the white. These form a story of varying density, but never constituting over one-half of the trees, slightly above the broad-leaf trees; or are coordinate with them and fewer in number. As the quality of the soil improves, either as regards fertility or constant proportion of moisture, and the individual specimens composing the broad-leaf element reach a larger size, the pines become fewer in number, restricted in kind to those attaining the greater size, the white and short-leaf, and are confined to the more rocky and shallow or sandy-soiled crests, and eventually are crowded out; either because the broad-leaf trees overshade the mature light-loving pines, or because their shade becomes too deep for the growth of the young plant.

DISTINCTIVE GROWTH.

The forests of the lower mountains approach in the character of their economic trees those of the western gneisses of the Piedmont plateau. The pines, except the short-leaf and the scrub (Jersey) are usually kinds which are not frequent in any part of the Piedmont plateau region; the chestnut oak becomes frequent; the post oak and Spanish oak do not occur at all over the larger part of the area; and the red oak, shingle oak, and chestnut oak become conspicuous and valuable trees.

The forests of the lower mountains are separable into three divisions: (1) that in which the Table mountain and pitch pines are the dominant resinous trees; (2) that in which the short-leaf, pitch, and scrub pines are dominant; (3) that in which the white pine is the dominant tree.

TABLE MOUNTAIN PINE DIVISION.

The area in which the Table mountain and pitch pines are the important pine timber trees embraces the eastern and southern slopes of the Blue Ridge, with the outlying spurs, from Georgia to Virginia, and the groups of the Brushy, South and Sauratown mountains. With these pines is to be found the short-leaf pine, which becomes more abundant as the elevation decreases and the soil become deeper and less rugged. The slopes of this range are steep; the soils are shallow loams or sandy loams, eroding rapidly under denudation, and, when cleared, restocking slowly on the cessation of cultivation. The broad-leaf trees which are associated with the pines are chiefly the scarlet and chestnut oaks and the chestnut. These form a low, open growth, seldom exceeding fifty or sixty feet in height. There is no underwood, and it is only occasionally that young trees are found, and these are for the most part stump or stool-shoots from trees the tops of which have been killed by the frequent fires which ravage these forests. Old trees, particularly oaks and chestnuts, show many defects from these fires, chiefly short and limby boles and hollows. Pasturing cattle and ranging swine are regularly practiced; firing is done to improve the grass crop and secure young stool-shoots in the spring; and to clear off the litter before the fall of chestnuts and acorns in the autumn. Locally, white pine occurs. Their boles, however, are short, limby and frequently defective, the heartwood being subject to the attack of Trametes pini, which caused defective stocks. The Carolina hemlock, the bark of which possesses the same tanning properties as that of the hemlock, is confined for the most part to the eastern slope of the Blue Ridge. Locally abundant, it is found at intervals along this mountain chain, to the west of it on rugged cliffs along the north and south forks of the Estatoe river in Mitchell county; the South Fork of New river in Ashe county; the gorge of the Doe river; and in the southeastern parts of Macon and Jackson counties, and in one locality over forty miles to the east of this range, the Sauratown mountains.

In the deep, narrow hollows which indent the eastern slopes of the Blue Ridge, the black walnut grew more abundantly and reached a larger size than elsewhere in this State; but it has been largely removed, and there are now only a few small trees. Of the locust, yellow poplar, and white oak which grew with it, only the white oak is still standing in large quantities. The timber in the hollows, where there are few pines and but occasional hemlocks, has been less damaged by fires than that of the drier and more exposed slopes. Browsing cattle, however, have checked the growth of most of the young broad-leaf trees.

MERCHANTABLE TIMBER OF THE TABLE MOUNTAIN PINE BELT.

There is now comparatively little merchantable timber lying along the Blue Ridge. Locally there is white pine, and yellow pine of several species suitable for milling purposes; and in the hollows some yellow poplar, white oak and chestnut suitable for lumber. White oak and chestnut oak railway tie-timber is abundant, and large quantities of white and chestnut oak tan bark are obtainable. Lumber mills obtaining their logs from these forests are in operation at Lenoir and Hickory, and smaller mills elsewhere. A tannery at Morganton depends on these forests largely for its oak bark. Fires have damaged these forests more than those of any other part of the State except the pine woods of the southeastern counties.

The forests cover nearly the entire area. The farms are few and confined almost entirely to the narrow alluvial bottoms; a few clearings have been made on the more gentle slopes or broader rounded crests. Some bottoms have been permanently damaged by washing during floods and the deposition of a heavy mud sediment on the surface of the loams. Old fields are seeded chiefly by the short-leaf, scrub and northern pitch pines; less frequently by the white. Sometimes they are all mixed. Such second growth is, however, inconsiderable.

The forests are capable of producing pine—short-leaf, and some white—together with chestnut oak on the slopes and crests; while walnut, yellow poplar, white oak and locust reach a large size in the hollows.

IMPROVEMENT OF THE FORESTS.

A complete cessation of the present annual firing is necessary, not only to insure the possibility of a vigorous stand of young trees, but to afford protection to the standing stock. Pasturage should not be permitted in such portions of the forest as contain young growth that can be injured. Hogs must be excluded after seed-years of nut-bearing trees. As there is now very little merchantable timber on the ridges, all management should have for its object the improvement of the general condition of the forest, regarding both density and preference for the more valuable kinds of trees. Few of the trees on the ridges will form large merchantable stocks; their utilization extends only to small pine milling-timber, oak railway ties, oak and Carolina hemlock tanbark, small chestnut and locust timber for posts and construction.

The trees naturally growing here are light-demanding, except the chestnut, the white oak and white pine, all of which will endure some shade; the chestnut the deepest and the longest, the white pine least and for the shortest time.

The chestnut, chestnut oak and the white oak can be relied on for reproduction from stump and stool-shoots, the chestnut sprouting most vigorously and from the largest-sized stumps, and the white oak least vigorously and from the smallest stumps. The locust frequently sprouts from small stumps, also from suckers under a thin cover.

SHORT-LEAF AND PITCH PINE FORESTS.

The area in which the short-leaf and pitch with the scrub (Jersey) pine are the dominant resinous trees, embraces the basin of the French Broad river in Buncombe and Madison counties, the river-hills of the Swannanoa, those of the French Broad in Henderson county, and the lower hills in Haywood, Swain, Jackson, Macon, Cherokee and Graham counties, lying below an elevation of 2,800 feet above sea level. The surface of this area is broken and rugged, the hills often steep, between them, along the rivers and smaller streams, lying narrow alluvial tracts. The lowest elevations are found on the eroded slopes of the Asheville basin and along the waters of the Little Tennessee river, where at the lowest limits the altitude is not over 2,000 feet.

The upland soils are stiff, mostly even-grained loams, rarely sandy. Although generally deep and derived from disintegration *in situ* of gneiss, or, in Cherokee and Graham counties, slates, they are, on the whole, not fertile; those of the lowlands are rich sedimentary loams with much vegetable matter along the smaller streams; along the larger streams are loams similar to those on the smaller ones, but more sandy and less fertile.

The hills erode rapidly on their shoulders when unprotected. Old fields, however, are generally quickly seeded in native grasses, which form a retentive turf, and after a longer time pines appear.

The short-leaf, pitch and scrub (Jersey) pines are the characteristic conifurs. The broad-leaf trees which grow with them are chiefly the white, black, scarlet and chestnut oaks, chestnut, and hickory. Of these the white oak is first in numbers and importance. It forms from .1 to .5 of the entire forest, being most abundant along the slopes; black oaks and pine superseding it towards the crests; other broad-leaf trees toward the bottoms.

The pines form from .1 to .3 of the forest, being in greatest abundance in the Asheville basin and at the lower elevations.

CONDITION OF THE PINE FORESTS.

The short leaf and pitch pine forest covers a little more than one-half of the area, and is largely of these pines mixed with broad-leaf trees less than one-twentieth of the forest being pure pine regrowth in old fields. It is divided chiefly among small farms. On the uplands it is decidedly irregular, the cover broken by the indiscriminate removal of mature trees, the young growth beneath representing all ages. Where pastured and burned the forest floor is poor and the young growth not abundant. On the best soils these trees attain an average height of from 60 to 80 feet: on the poorer and along the sandier crests from 50 to 70 feet, the pines being the taller on the poorer soils but being overtopped or equaled in height by the broad-leaf trees in more fertile situations. The density is generally less than three-fourths of what it should be, natural reproduction being prevented by excessive and injudicious lumbering, pasturage, and burning. In many places the mature pines have been largely removed, oaks taking their places, but where there has been no burning many young pines are to be seen. The milling poplar and oak have been largely removed; poplar, from its shade-demanding requirements, the fact that the young plants are eagerly sought for by browsing cattle, and the removal to a great extent of the seed-bearing trees, is reproducing itself only to a limited degree; the chestnut, the white oak, black oak, and scarlet oak more freely.

Where the woodland has been protected for a great many years the mature timber shows little damage from fires or the effects of pasturing; there are only a few localities, however, where this is the case. Black oaks and chestnuts often have hollows from fires; more rarely pines and white oak.

The merchantable timber still standing is chiefly valuable as a source of supply for the numerous farms to which the woodland is attached and the small towns lying near them.

At present the forest is about exhausted, so far as the milling pine and yellow poplar is concerned. Oak and chestnut, though chiefly of a small size, are still to be obtained.

The forest is capable of yielding milling timber, fuel, railway ties, and fencing, for most of which a local market can be found.

IMPROVEMENT OF THE FORESTS

Protection from fire and cattle should be afforded where this is not already done. Defective trees, or those of inferior kinds, which are interfering with young growth beneath them should be removed. Proximity to farms will generally allow this to be done as such wood can be made use of as fuel. The growth should be allowed to thicken up to restore the humus and give the requisite shade.

Most of the land here is too broken to permit clean cuttings without danger of great injury to the soil. Pure growth of pine, on the gentler slopes could, however, be cut without danger of excessive washing. Naturally the forest requires selection cutting.

The pines and yellow poplar require reproduction in all cases from seed. To supply smaller wood for fuel and farm use most of the broad leaf-trees can be reproduced from stool-shoots.

Fields are seeded by pines and to some extent by locust; rarely by nut-bearing trees. The yellow poplar will propagate in thin woods on a damp soil as the seedlings require some shade. The short-leaf is the most valuable of the pines, and though at first not the most rapid-growing, the Jersey or scrub out growing it, should be protected at the expense of the others if it is intended to permit the trees to reach a large size.

WHITE PINE FORESTS.

The woodland in which white pine is the dominant coniferous tree is not extensive, but lies in isolated, small bodies along the crest, and southern and eastern slopes of the Blue Ridge, or on the low hills on the west.

The most extensive forests containing white pine lie in the southeastern part of Ashe county, extending, though interrupted, up the valley of the South Fork of New river into Watauga county; in the upper valley of the Linville river in Mitchell county; in the valley of the French Broad river in Transylvania county; and in the southern parts of Macon and Jackson counties, at an elevation of 2,800 to 3,800 feet above sea level, extensive forests seldom being found above the higher limit, or perfect individual development attained below the lower. The total area of white pine forest is not over 200,000 acres.

In a few places on the southern slope of the Blue Ridge, particularly along the headwaters of the Elk, Yadkin, and Roaring rivers in Wilkes and McDowell counties, and the upper valley of the Johns river, the white pine is associated with yellow pines as well as with deciduous trees, but the trees are generally short-boled and neither so large nor tall as those growing at a higher elevation to the west of this range.

Single specimens or small groups of trees are locally dispersed in the broad-leaf forests throughout the mountain counties between the limits of altitude given above. Their value, however, is potential rather than actual, since, growing on the thin-soiled crests of ridges and failing to develop clear shafts, they lack the essential requirements of timber trees; but, as possible sources for the dissemination of seed either in denuded land or in thinned woodland, especially where pastured, their utility may become great. Such groups of trees are to be found in Alleghany, Madison, Haywood, and Graham counties, besides in portions of other counties in which bodies of more compact growth occur.

The white pine is generally associated with white, black, red, and less often, scarlet and chestnut oaks, chestnut, and hickory, when growing along the crests or flanks of rolling hills, on coarse, often porous, gravelly, loamy soils; or less frequently with hemlock, sweet and yellow birch, red oak, and pitch pine along moist or wet fluvial deposits on fertile, loamy soils.

CONDITION OF THE WHITE PINE FORESTS.

In some localities these forests have been extensively culled or lumbered; in others, their integrity is as yet scarcely broken. Where they have not been dismembered two groups of trees are represented: white pine, forming an upper group, from 100 to 150 feet in height, and usually .1 to .3 of the growth; beneath this, a group of deciduous trees of varying height, but rarely over 90 or less than 70 feet, composed chiefly of white, black, and chestnut oak, and chestnut. Of these, white oak is the most abundant.

Where lumbered they are irregular; occasional decrepit white pines overtopping the deciduous growth, which, however, has been cut into only locally; but where around settlements both pine and hardwoods have been culled the entire cover is broken and thin.

One of the effects of pasturing forest lands is that while young plants of deciduous trees have been destroyed, pines have increased; but where burning is practiced, sourwood, scarlet oak, white oak and other vigorous and free sprouters have propagated most rapidly, while pines have diminished.

In a few places a heavy underwood of the great laurel, less commonly of laurel (ivy), grows beneath the deciduous trees, forming a thicket 10 to 15 feet in height, with many crooked stocks rising from the same burly roots. Where this underwood is present the deciduous growth above is usually more open, but browsing cattle have inflicted less damage on young growth of tender-leaf species, and fires are less frequent; the humus is thick and the soil unimpaired.

There are only few farms in the area of white pine forest; probably less than 20 per cent. of the total acreage being under cultivation. In Ashe and Watauga counties the forest is divided chiefly among small farms; in Mitchell and Macon are large areas thinly settled. On the farms the woodland has been more largely culled and pastured, and its density will seldom be above two-thirds of the normal condition.

A few groves of vigorous young pines have sprung up in the fields from the self-sown seed of neighboring forest trees; but such groves are not common. Young pines are increasing in the woodland only to an inconsiderable extent. Much of the bottom land on which this pine grows has already been deforested, and it is probable that all of it will eventually be brought under cultivation, as the soil is of superior quality and stands tillage better than that of the adjacent hills. The forests on the hills, however, should be regarded as permanent, and care bestowed on them accordingly.

Larger pines, being protected by their thick bark, are damaged only to a slight extent by fires; young ones while the bark is yet smooth are more readily scorched and injured and sometime killed. Oaks and chestnuts show hollows from the effects of fires, particularly along ridges and in dry woods.

MERCHANTABLE TIMBER OF THE WHITE PINE FORESTS

Extensive areas of unlumbered forest still exist in Transylvania, Macon and Mitchell counties. The standing trees will yield fairly good lumber, though it is seldom that over two cuts, 16 feet in length, from which clear boards are obtainable, can be secured from one tree. Smaller bodies yielding a larger proportion of knotty timber are standing in Wilkes, McDowell, and Caldwell counties. Lumbering is in progress in Mitchell, Caldwell, and Wilkes counties.

IMPROVEMENT OF THE WHITE PINE FORESTS.

At the higher altitudes these forests are capable of producing pine milling timber of good quality, large chestnut and oak timber, ties and fencing. At present there is no local market. Below 2,000 feet the pines fail to clear their stocks and the growth is slower, so that very little lumber free from knots can be made from any trunk.

In places where there is young growth, protection from fire and cattle is imperative. Defective seed-bearing pines, which are not seriously interfering with young growth, should be allowed to remain as seed-trees, both in lumbering and where culling is carried on. It is essential that the growth be maintained at the fullest possible density until the young pines have cleared themselves, as otherwise from their tendency towards perfect symmetry in the development of most of the buds into limbs, the boles will be limby and knotty. As the young trees require small growing-space, the crowns standing much lateral compression and being to a certain extent shade-bearing, the density can scarcely be too great until the trees reach the size of large poles. The rate of height-growth is more rapid than that of any of the associated species, averaging for the first fifty years over a foot of height-growth a year; and for the first ten years nearly 18 inches a year, so that the young trees quickly free themselves from the shade of broad-leaf trees when growing with them.

The white pine seeds many old fields, but not so quickly or thoroughly as the short-leaf pine. In such groves of pure pine the stand should be kept thick and should not be culled until the height-growth is made. If grown in pure wood, selection cutting would best preserve the factors of the locality, but there are many places where clear cutting would be permissible. The proportion of pine in wood mixed with broad-leaf trees can well be increased to twice or even three times what it is at present, as it is the most valuable tree growing on these gravelly hills. The pine begins to seed in abundance when about forty or forty-five years old, and seed are borne abundantly once in 2 or 3 years.

THE FORESTS OF THE HIGHER MOUNTAINS.

These forests embrace all the woodland lying at an elevation above that of the forests of the lower hills and below 5,000 feet. The lower limit of their distribution is about 3,000 feet, but on southern slopes, particularly along the Blue Ridge, the distinctive character of the growth does not appear for several hundred feet above this limit, following closely the isothermal with the variation incidental to changes in moisture in the soil, depth of soil, and its physical characters.

The greater part of the woodland of the counties of Alleghany, Ashe, Watauga, Mitchell, and Yancey is so situated; and in the mountain region to the south of these counties, the woodland lying around the base and on the slopes of the larger mountain masses.

About one-third of the area originally occupied by these forests is now under tillage or in meadow; the rest is more nearly virgin than any other considerable extent of forest to be found in this State. The situation, on steep slopes or rugged declivities, the distance from large waterways, and the inaccessibility of the region to railways, has rendered it impossible to economically remove any but the most valuable timbers; while difficulty of tillage, and the short growing-season have tended to prevent extensive cultivation of those lands lying above 3,500 feet elevation.

SOILS OF THE HIGHER MOUNTAINS.

The soils are rather fine and even-grained loams, gray or red in color, or black from organic ingredients; the loamy and generally stiffer sub-soils red or gray. Over the larger part of the area they are derived from the decomposition, *in situ*, of gneiss or gneissic rocks or schists, and are sufficiently deep for tree-growth, particularly along the lower slopes, where detritus washed from above has accumulated or obscurely marked river terraces exist.

In portions of Cherokee and Graham counties, and locally elsewhere, the soils derived from slates, quartzite and metamorphosed sandstones are shallower, thinner and not so favorable to tree-growth. The soils of the upper slopes are thinnest, the clayey particles being more largely washed out, and are sometimes shallow. Those of the sedimentary bottoms are more loamy and coarser, with more organic constituents and less clayey, sometimes underlaid by pipe clay, and ill-drained. The soils of the lower slopes are generally deep and are the most clayey.

FOREST TREES OF THE HIGHER MOUNTAINS.

The forests of the high mountains may be divided into (1) those lying on the crests, and on the slopes facing the south, and (2) those of the north slopes and hollows, and along the bottom lands. The soils of south hill-sides are drier and are thinner than those on slopes with a northerly aspect, and the amount of light and heat is greater than is secured on hill-sides with equal inclination to the north, and the trees are consequently of more light-demanding kinds.

The trees occurring on the slopes facing the north and in the hollows are: hemlock, birches, maples, beech, chestnut, red oak, white oak, great laurel, yellow poplar, white ash, cucumber,

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MIXED HARDWOOD FOREST OF THE MOUNTAIN REGION buckeye. The characteristic trees which are to be found on the northern slopes and hollows are: hemlock, great laurel, sweet birch, yellow birch. (Plate XXIII.)

On the southern slopes and along the gravelly crests of the hills the growth is less varied, being largely composed of chestnut, white oak, red oak, black oak, and chestnut oak. The forest on southern slopes is less dense than on northern and the trees are smaller.

CONDITION OF THE FORESTS.

The cover of these forests has scarcely been broken, the tops of the trees presenting a nearly uniform surface throughout, the crowns closely interlocking and forming a dense shade. Beneath them is a good floor, usually free from grass and weeds and generally with a deep humus.

On the best soils along the lower slopes and bottoms the forests attain an average height of from 90 to 120 feet, with clear shafts of 60 to 90 feet, bearing narrow crowns. On the poorer and thinner soils, particularly towards the upper slopes, the forests become low and less dense, the cover often thin and open, the boles of the trees shorter, generally crooked and knotty, bearing great spreading crowns.

In very many places there are two groups of trees represented in the forest: a dominant arborescent growth of large trees varied as to species and forming the commercially valuable timbers; beneath them a group of evergreen shrubs or under-trees, often of great density, formed of the great rhododendron and laurel. In most places there is present a vigorous young growth of the dominant group of trees if they are shade-bearing species: beech, birch, and hemlock on the wetter soils; sugar maple and occasionally red oak on the drier, the young growth forming thickets, sometimes of pure growth, beneath the parent trees; but where the cover has been broken by trees being removed in lumbering or by windfalls, irregular thickets of light-loving species spring up: chestnut, cucumber tree, yellow poplar, white ash, white and red oaks, which can endure a deep shade only for a short time.

Browsing cattle have damaged young growth to a great extent, especially such kinds as will not endure, beneath the shade of other trees, repeated cropping: yellow poplar, white ash and oak; sugar maple and beech to a less degree. In many places about fallen trees and the openings made in lumbering, where there would be a heavy young stand, cattle have prevented its growth until thickets of brambles have sprung up within which young seedling trees find protection.

Forest fires have inflicted only slight injury either to standing timber or to young growth on the northern slopes, as the damp or fresh humus does not readily carry fire, but on the south sides much timber has been damaged.

MERCHANTABLE TIMBER OF THE HIGHER MOUNTAINS.

Merchantable trees of walnut and cherry, which have been much sought after for cabinet-making have been nearly all removed. Occasionally large trees of the former kind are to be found, and a few small bodies of the latter still exist upon the higher mountains. Yellow poplar and cucumber-tree, being the chief building materials of the region, have largely been removed; large bodies are still to be found, however, intact, particularly in Yancey, Mitchell, and Transylvania counties, and smaller ones in many other places in the mountains. Floating timbers, white pine, yellow poplar, ash and chestnut have been largely removed from the lower valley of the French Broad to supply mills at Asheville. Oak has been cut nowhere except for local use. The Little Tennessee river and its tributaries have had much of the floating timber removed from them near the water courses. Hemlock has been cut only around Cranberry and adjacent to some of the larger water courses. Ash has been generally removed wherever means of transportation were available. Birch, except curly yellow birch, has never been lumbered, and the same is true of maple, beech, and lin (basswood).

Chestnut has been locally removed. Around all settlements and farming communities a great portion of the oak, chestnut and poplar has been removed, and the forests are much broken.

FOREST INDUSTRIES OF THE MOUNTAIN REGION.

There are mills sawing lumber at Linville, Cranberry, Asheville and Hot Springs and small ones along and near the railways. The Watauga, Toe, Little Tennessee river and its tributaries afford transportation, the timber going to various places in East Tennessee, chiefly, though, tc Knoxville. Hemlock is barked around Cranberry for tanneries at Elizabethton, Tenn., and chestnut oak is barked around Asheville for local tanneries. No use is made of the hemlock stocks after they have been barked; the oak is converted into cordwood and sold for fuel. Walnut, curly ash and curly birch are shipped in the log to veneering factories. The best quality of yellow poplar, ash, and oak timber from here goes chiefly to Philadelphia and Cincinnati, and other inland points, sawn in 8 to 12 inch squares. Locust pins are manufactured at Bryson City, Waynesville and other places. Only a few staves are made and not many white oak railway ties are produced.

In the more remote districts birch oil (*oil of wintergreen*) from the sweet birch is distilled in crude home-made retorts, constructed of wood, lined with clay and with metal bottoms. This was an extensive and profitable industry until overproduction reduced the price. The timber of trees thus barked is rarely used.

Among other smaller industries, which are carried on with more or less profit, are keeping bees, in sections where the sourwood, yellow poplar and lin are abundant, to utilize their flowers for honey; the sale of nuts from the native chestnut; and the manufacture of syrup and sugar from the maples.

THE FORESTS OF THE MOUNTAIN SUMMITS.

The black spruce is the characteristic tree of these forests. With it is generally associated the Carolina balsam, the lower limit of which is about 300 feet above that of the black spruce.

The mountain ash (mountain sumach), striped and spiked maples and wild red cherry are small broad-leaf trees which are usually found growing, though not abundantly, with the balsam and spruce.

These forests of sombre evergreens lie along the summits of the highest mountains, seldom being found on peaks with an elevation of less than 5,500 feet above sea level. They cap the Grandfather and the adjacent pinnacle of the Grandmother; encircle in a great belt the rounded bald of the Roan; stretch along the numerous massive peaks of the Blacks from Bolen's Pyramid to the Pinnacle; lie on the top of Pisgah; cover the crests and upper slopes of the Great Smoky mountains and the cross-chain of the Balsams as a nearly continuous forest for a distance of almost thirty miles, and crown the tops of the higher peaks of the southern parts of Macon and Jackson counties. From their dark foliage the Blacks and Great Smoky mountains derive their names, and the Balsam mountains from the growth upon them. The lower limits of the forests lie on an average above 5,000 feet above sea level, or a little less. On north slopes, within deep and cool hollows, they extend as low as 4,700 on the Grandfather mountain, 4,600 feet at the head of Caney river in the Blacks, and 4,500 feet at the head of Forney's creek in the Great Smoky mountains, while on bold south slopes, as occur in the Blacks and elsewhere, the broad-leaf trees will often extend as high as 5,300 or 5,500 feet.

Commercially these forests are at present unimportant.

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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

BULLETIN No. 7.

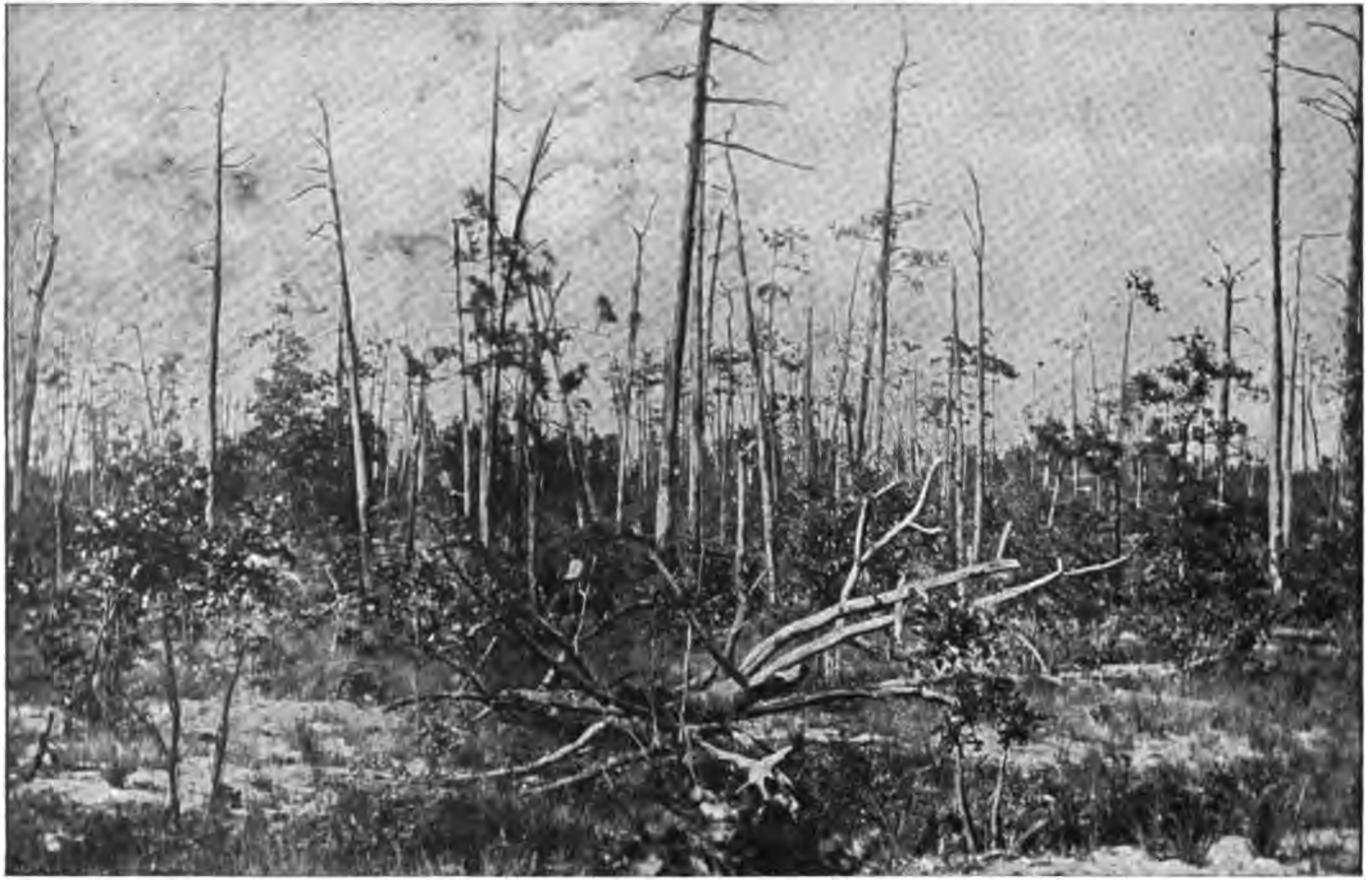
FOREST FIRES: THEIR DESTRUCTIVE WORK, CAUSES, AND PREVENTION.

BY

W. W. ASHE,

IN CHARGE OF FOREST INVESTIGATION.

RALEIGH:
Josephus Daniels, State Printer and Binder.
1895.



LONG-LEAF PINE FOREST A FEW MONTHS AFTER A FIRE; MOORE COUNTY.

[Forest fires in North Carolina have destroyed more timber than lumbermen have cut.]

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LETTER OF TRANSMITTAL.

RALEIGH, N. C., January 31, 1895.

To his Excellency, HON. ELIAS CARR,
Governor of North Carolina.

SIR:—I have the honor to submit herewith for publication as Bulletin No. 7 of the Survey series, a paper by Mr. W. W. Ashe, on the subject of Forest Fires in North Carolina; their destructive work, causes and prevention.

It is earnestly hoped that the people of the State can be induced to give this subject the careful consideration which it deserves, and that such measures can be adopted as will greatly decrease both the number and extent of these fires.

Yours obediently,
J. A. HOLMES,
State Geologist.

INTRODUCTION.

The object which it is hoped will be accomplished in the publication of this bulletin is to place in the hands of the more intelligent citizens of the State facts showing the extent to which our forests are being injured by fires, and the importance of adopting such measures as will check or stop this great evil.

Nothing better illustrates the state of public opinion in North Carolina on the subject of forest fires than that the fact that the State law prohibiting such fires, except under certain conditions, has remained on the statute books practically unchanged and unenforced for more than a century. And nothing more forcibly illustrates the destructive work of these fires than the fact that whereas the long-leaf pine, which has for so long a time supplied both lumber and naval store products, a century ago was a common tree throughout the whole of eastern North Carolina, now it is almost unknown north of the Neuse river; and south of this river, at its present rate of destruction, in two decades more it will cease to be a tree of economic importance. Of course the lumbermen have made great inroads on the long-leaf pine forests. But even of the full grown trees the fires have destroyed more than the lumbermen have cut; and so completely have these fires destroyed the young growth of long-leaf pine that in many counties scarcely a specimen can now be found to indicate where once grew valuable forests of this tree.

Among the hardwoods or deciduous trees of the middle and western counties, during the century, the fires have been of incalculable damage to the forests, and in ways that appear to attract but little attention: (1) They have injured the mature trees at their bases, causing them to decay and die; (2) they have destroyed the young growth of the less hardy (but sometimes more valuable) varieties; (3) in case of the more hardy varieties the young growth has been frequently killed to the ground, and the new sprouts from the roots have imperfect bases and make subsequently imperfect trees; (4) these fires destroy the humus on the surface of the soil, and thereby seriously injure its productive capacity.

The injuries resulting from forest fires are thus so manifold and extensive that it is difficult to estimate them accurately on a money basis. But adding to the estimate given on pages 53 and 54 of this report the damage resulting from the destruction of the young growth and the humus, the aggregate damages will doubtless be several million dollars per annum.

Many of the forest fires have accidental origins, such as sparks from locomotives or other engines, hunting parties or camping parties at night, or from burning brush piles during the day. But it is estimated that at least two-thirds of these fires are of intentional origin, and in the majority of such cases the object that is expected to be gained in starting the fires is the improvement of the pasturage. In some cases the result of the burning may be a temporary improvement in that direction, but it must be borne in mind that these fires also destroy much of the grass and annual and perennial herbs and shrubs, by burning both the seeds and the plants, and that in this way, in the long run, even the pasturage in the forest is injured rather than improved by these repeated fires. Unquestionably the wisest policy to adopt, and the policy that has been adopted in all civilized countries, is to provide grass lands for the pasturage of cattle, and protect the forests against fires and all other destructive agencies, because of their value as forests.

The total value of the forest products in North Carolina, as shown on pages 40 and 41, will range from $20,000,000 to $25,000,000 per annum. The total value of all the cattle in the State is about $5,000,000—a sum which is only between one-fourth and one-fifth of the annual value of the forest products; a sum but little if any greater than the amount of the annual damages to the forests of the State caused by fires.

It must also be borne in mind in this connection that while the total yearly growth of our forests is equivalent to about 9,000,000 cords of wood, the amount of timber now annually cut from these forests is equivalent to 11,000,000 cords. We are thus not only using the interest on this forest investment, but are making rapid inroads on the principal. In the eastern counties we are cutting pine forests to replace which, from the seed, will require from fifty to one hundred years: while in the western counties it will require from one to three centuries to replace the splendid hardwood forests of the rich mountain slopes.

The bare statement of these facts ought to bring us at once to a realization of the truth that the protection and perpetuation of our forest wealth deserve far more consideration than they have received. The right of the present generation to use the mature trees of the existing forests no one will deny; nor will any reasonable man deny that the younger forest growth of to-day should be preserved as the rightful heritage of the next generation. And yet, in the treatment of our timber lands, this latter principle appears to be lost sight of entirely.

It is to be hoped that this matter will be taken up by the press of the State—by the more intelligent citizens of every county and by the lumbermen themselves, who, as much as any other class, are to be benefited by the perpetuation of our forests—and that the agitation may be continued until forest fires are of rare occurrence, and until every sale or lease of timber rights will be conditioned on a rigid protection of the young forest growth against the ax and all other destructive agencies.

If such a wise policy is promptly and permanently adopted the forests of the State may continue for centuries to be a source of wealth to her people. If, on the other hand, the present system of waste and destruction continues to prevail, we will not have gone far into the new century before we are brought to a realization of the fact that our splendid forests are a thing of the past.

J. A. Holmes,
State Geologist.

FOREST FIRES: THEIR DESTRUCTIVE WORK, CAUSES, AND PREVENTION.

BY W. W. ASHE.

FOREST FIRES.

The past year (1894), one of considerable drought, witnessed extensive and destructive forest fires in the Northwestern States, involving the loss of over five hundred lives and millions of dollars worth of timber and other property. These fires in the Northwest occurred in a thinly-settled country. But even in eastern Massachusetts, a district dotted with towns, farms and country seats, fires occurred in the latter part of summer, which for several days baffled every attempt toward extinguishing them; and this was not done until a large loss had been incurred. In Massachusetts such fires were unprecedented, for the woodland is carefully protected, and forest fires are only of accidental occurrence. The same cannot be said in respect to other States, least of all for those in which lumbering and the handling of forest products are extensive industries. There is, in most parts of this country, a recklessness amongst those deriving their livelihood from the forest, which it seems, is never satisfied until the source of their maintenance has been destroyed.

The degree of exemption from extensive forest fires which North Carolina has enjoyed during the past year is unusual. In other recent years there have been single fires the losses from which aggregated hundreds of thousands of dollars. Bladen, Cumberland, Harnett and Moore counties have been the seats of such conflagrations since 1890. Although only the large fires attract much attention, the damage and loss occasioned by them does not, on the whole, exceed the destruction caused by the thousands of smaller fires which, each year, pass, almost unnoticed, through the forests. The damage resulting from these smaller fires is inconsiderable, as far as standing timber is concerned and, unless the destruction of other property is involved, they are in many localities regarded as beneficial rather than otherwise. Their damage, however, is great, although a superficial examination may fail to reveal it. Their continued repetition means the gradual killing of the forest or the reduction of it to a few species, which are physically capable of withstanding scorching heat, which seed or reproduce themselves abundantly and at an early age, and whose young seedlings are exceedingly hardy.

LOSSES FROM FOREST FIRES IN 1880.

Of all the destructive agencies to which woodland is exposed none is surer in its effects or more rapid in its execution than fire. By the census of 1880 the value of the property destroyed by forest fires in the inhabited parts of the United States, during one year, was ascertained to be over $25,000,000; and even this immense amount is supposed to represent only a part of the property destroyed, since no reports were made of many fires. The same authority gives the damage from forest fires in North Carolina for that year as having reached $357,000, and the number of acres burnt over as amounting to 546,000. The value of the property destroyed (which was largely standing timber) was equal to that of all the standing timber which was cut in the State during that year for saw-logs. And equaling the irreparable damage to standing timber is the injury to the soil from these frequent burnings. The harm thus occasioned is rarely even considered.

THE ATTITUDE OF TIMBER OWNERS TOWARDS FOREST UNDERGROWTH.

In circulars sent to well-informed persons in the extreme eastern and western counties a question was inserted concerning the attitude of timber owners toward the young growth in the forest. In answering this many correspondents gave prominence to the fact that it was considered a nuisance to have the young growth in the forests, and one of the objects of burning, and benefits derived therefrom, was keeping the thicket of saplings killed down. Where it is not desired to keep the young growth down in order to secure a slender pasturage the main object in view appears to be to keep the woods open for hunting or to facilitate passage through them.

The object chiefly desired, then, in burning is pasturage; the object attained is the destruction of all young growth. While it is regarded as proper and advantageous to secure the maintenance of the mature trees, the utilization of which is possible at any time, and which represent, *prima facie*, a specific market value, no protection is accorded the young growth to enable it to survive. The feeling towards it passes beyond mere disinterest. If the young growth is coniferous it is regarded with disfavor, since it affords no food material for cattle; if it is of broad-leaved trees its legitimate utilization is realized when cattle are browsing upon it. If, in spite of the depredations of live stock, the young growth persists in growing, which is usually the case, it is burned down to effectually check it. The end aimed at in this is to keep the woods open; for in dense woods pasturage grasses do not grow and most broad-leaved seedlings will be shaded out. The pasturage obtained by this means is insignificant, the herbage of many acres being required for the support of a single animal, and it is only secured at the expense of a valuable forest undergrowth.

KINDS OF FOREST FIRES.

The fires in most sections of this State are leaf or grass fires; that is, the dry leaves or dead grass form the fuel which carries the flames. Practically all the fires in the western counties are *leaf fires;* it is seldom that there is sufficient undergrowth present for the fire to be communicated to that, although the undergrowth is usually all killed. In the south-eastern counties, in the long-leaf pine belt, the fires are usually carried by the high and thick grasses which cover the forest soil wherever the woods are at all open. These grasses are hardy perennials like *Aristida stricta, Andropogon tener, A. virginicus, A. elliotti,* and *A. argentius;* the first one known as the wire-grass of the pine barrens, the others as broom grasses or broom-straws or "sedge."

Fire frequently escapes from the grass to the pine trees. In pine woods where the undergrowth is thick, and more rarely in mixed woods, the brush frequently burns and occasions incalculable damage to the standing timber; and in swamps with a heavy undergrowth, particularly peaty ones with a growth of white cedar (juniper), fires in dry seasons will consume both undergrowth and brush and mature trees. These fires of course are the most destructive and are well called *timber fires.*

ULTIMATE RESULTS OF FOREST FIRES.

To ascertain what will be the effects of the continued burning upon woodland there is no necessity to revert to the condition of some of the worn-out lands of southern Europe or to cite the instances from foreign writers of the destitution and barrenness which have succeeded the continual burning of the forests there. As concrete evidence of the destructiveness of numerous small fires as can be adduced is the denuded state of a large part of the waste sand lands in the south-eastern counties of North Carolina. The original forests of long-leaf pine in that section have gradually been consumed. More, it can be safely said, has been burnt than converted into lumber. This has seriously affected the supply of merchantable timber. Furthermore, these ravages have largely influenced the supply of the future, in its abundance, quality and variety, as well as the soil in its ability to sustain a forestal growth. Already throughout the eastern section of the State profound changes have been induced in the character of the forest flora of the uplands and, in places, irreparable damage has been suffered by the forest lands. Changes, too, have been produced in the character of the sylva of the hill country and the mountains. These changes, however, are not as generally diffused as those which have taken place in the lower districts, and are less impressive, since they have influenced the varieties in a mixed hardwood forest, instead of the struggle for supremacy between two dissimilar pines or between a pine and an oak growth. In connection with the destruction of the long-leaf pine forests it can be said that along with it is being destroyed one of the most important industries in the State—that of gathering and manufacturing resinous products. The aggregate of these products has decreased since 1870 over two-thirds, with a prospect in the near future of a total failure of the industry in this State from the inability to secure new and profitable pineries to tap for turpentine, as the old ones, from long continued boxing, become unprofitable and are abandoned.

THE CHANGES PRODUCED IN THE LONG-LEAF PINE FORESTS BY FIRES.

NORTH OF THE NEUSE RIVER the long-leaf pine formerly extended over the drier sandy land, in an almost unbroken forest, as far north as southern Virginia. This pine has gradually been killed out by fires or removed for commercial purposes, so. that but little of the original forest growth now remains. Fortunately there has been a tree ready to take its place, the value of which, for lumber, is but little less than that of the long-leaf pine. This tree is the loblolly pine, which is known throughout the eastern section of this State as *short-leaf*, *rosemary*, *old field* or *swamp* pine. Mixed with this second-growth loblolly pine is a vigorous undergrowth of young post, white and red oaks. These, however, do not reach sufficient size to enter into construction, since, after reaching a diameter of fifteen or twenty inches, they generally succumb to internal decay, the soil being unsuited to their growth. This replacement of the long-leaf pine by the loblolly has been so gradual that in places the forest appears, as it stands to-day, to be composed of a mixed growth of these two species. The fact is significant, however, that nowhere is there any young growth of the long-leaf pine. All trees of that species are mature trees, while the loblolly pine is seen in all stages of development from tender seedlings to trees in full maturity.

SOUTH OF THE NEUSE RIVER the effects of the fires have been more marked. The upland soils in this south-east section are of two kinds, the sandy loams which form the level pine lands and the sandy soils which form the pine sand-hills. This sand occurs in a loose layer, from a few inches to many feet in thickness, lying above the more fertile loams. The loams are similar in character to the greater part of the soils found north of the Neuse river, and on them, south as well as north of the Neuse river, the loblolly pine and a heterogeneous growth of small oaks have superseded the long-leaf pine. On the sand-hills the destruction of the long-leaf pine has been accompanied by no aftergrowth of loblolly pine, so that the result of the burnings is large areas of waste land covered only with a scattering growth of the sand black-jack oak, and other scrub oaks, or entirely denuded. The largest tracts of this waste land lie in the eastern counties of New Hanover, Wayne, Duplin, Pender, Onslow, Bladen, Columbus, Harnett, Sampson, Robeson, Brunswick and Moore.

The United States census of 1880 gives the area of the waste lands in these counties to be 105,705 acres. This included only the waste lands attached to farms, as old fields and fallow lands. An examination of these counties undertaken by the North Carolina Geological Survey in 1893 revealed the fact that the area of waste or unproductive forest lands then amounted to over 400,000 acres.

This entire area, amounting to about one-tenth of the acreage of these counties, has been reduced to its present condition almost entirely through the agency of fire. Besides the above, there are extensive areas of thinly timbered pine land far exceeding in extent the area of the waste lands. These are turpentine orchards, either still being worked or abandoned, the trees in which have been continually tapped for turpentine for twenty years or more, and now have their ranks so thinned as to scarcely deserve the name of woodland. The mature trees have one by one been destroyed by fire or prostrated by wind, broken where the collar of the bole was weakened by the deep turpentine boxes. There is nothing remarkable in the fact that the forests have become thinned by the usage of a century, but their openness below and the fact that no young pines are seen taking their place are worthy of the utmost consideration.

The loblolly pine although it quickly, by its winged seed and the frequency of its seeding, gains possession of lands with a moist or loamy soil and attains a medium size, producing a fair grade of timber, is yet incapable of growing on the dry, sandy land which forms a proportionately large part of the area of these south-eastern counties. Indeed if it once succeeds in gaining a foothold on the sand land, where the soil has been cultivated, it is incapable of maintaining there an uninterrupted growth until it becomes a large tree. It is naturally a tree of the lowlands, or rather of the better class of moist or wet loams, and when it does succeed in growing on the sandy lands under such altered conditions it forms only a low growth, with boles short and knotty. Besides rarely ever reaching a height of over fifty feet, it is subject in such situations to "dry-rot" or "red-heart." Associated with the long-leaf pine on this sterile soil are the sand black-jack oak and the highland willow oak, both of them "scrub oaks" incapable of yielding timber, and forming beneath the pines only a low and open growth. The litter of these oaks, with the dry wire-grass and broom-grass of the barrens, forms the fuel for the destructive fires.

CAUSE OF DECADENCE OF THE LONG-LEAF PINE.

As this is a subject of the utmost importance involving the timber growth, or rather the lack of timber growth, on an area of over half a million acres, it may be well to give more fully some of the causes which have, in conjunction with the fires, played important parts in the reduction of these areas to their present state of unproductiveness, and some of the peculiarities of the morphology and life process of the long-leaf pine which prevent it from succeeding in the struggle for existence with its competitors, while they successfully overcome the conditions imposed by man upon forest growth. As a comparison of the differences between the pines of this region and their relations to their environments has been discussed in a previous bulletin of the Survey, only a résumé of the salient points will here be given. These will embody the reason why the long-leaf pine fails while the loblolly pine thrives, even on what was once undebatable ground, entirely within the territory of pure long-leaf pine growth. The fructification, the seed, the seedling, life period and hardiness of the long-leaf pine, considered in their connection with fires, have important bearings on this subject.

THE SEED AND SEEDING OF THE LONG-LEAF PINE.

The long-leaf pine, with its fertility impaired by the drain on its vital resources due to the removal of the turpentine by boxing, produces seed abundantly only at irregular and infrequent intervals. A large pine mast occurred in 1845, another in 1872, and in 1892 there was a third, after an interval of twenty years.

In intermediate years the production of mast was small and localized. Since 1892 there has been no long-leaf pine mast at all in eastern North Carolina.

A great proportion of its seed, which are between one-fourth and one-half an inch long, are destroyed by fowls, rodents and hogs, which prefer this to all other kinds of mast. The seed, after falling as the cones open, during October and November and through the winter, are entirely exposed to these varied attacks until they have germinated and securely rooted, which happens in the following spring if the mast is late in falling, or, as is more often the case, if the mast falls in a warm, moist autumn season it germinates at once.

GROWTH OF THE LONG-LEAF PINE.

THE SEEDLING.—The growth of the young seedling of the long-leaf pine is exceedingly slow. The greater part of the vital vigor of the young plant is directed towards the root-system, which consists of an oblong, spindle-shaped tap-root with numerous fine roots diverting from its lower end. The tap-root increases rapidly in length, being fifteen to twenty inches long and one and one-half inches in diameter when the plant is only five years old. The stem, even until the fourth or fifth year, remains nearly stationary in height and only slowly increases in thickness to correspond with the increased diameter of the tap-root. It is during this stage of its development that the greatest number, perhaps as much as nine-tenths, of the young pines are destroyed. Being for so long a time stemless and surrounded by high grass, as is the case in the open woodland or where the merchantable trees have been removed, the young long-leaf pine, on account of its small size and tenderness, is liable to be killed or consumed by fires during a period three or four times as long as the loblolly pine or the scrub oaks in similar situations. A passing fire is apt to destroy nearly every seedling pine in its course. The hogs also destroy a great number of them in this early stage of their growth, by rooting them up to eat their large, succulent roots. Through these two agencies the greater part of the young pine growth is destroyed before it becomes fairly started in life.

LATER STAGES OF GROWTH.—At the termination of the first four or five years of growth, which may be said to form the seedling stage of existence, rapid height-growth begins. During the first few years of this period of height-growth the body axis rapidly develops in length at the expense of thickness, forming long, wand-like stems. During this period of its life wind-storms inflict severe damage upon the young growth, snapping off the slender stems or bending the flexible ones into inextricable masses. Fires, too, are still capable of doing great damage, since the loose, thin bark affords but slight protection to the living wood against heat. The resulting damage, however, will be most severe from spring fires, which occur when the new wood is forming and the leaves shooting. After a height of twenty to twenty-five feet is reached the height-growth is accompanied by rapid increase in diameter, and throughout the rest of the life period neither height nor diameter-growth alone takes place at the expense of proportional development elsewhere.

On the better class of soils at the expiration of twenty-five or thirty years the trees have attained a height of thirty to thirty-five feet and a proportionate diameter of ten to twelve inches. The rate of height-growth probably reaches its maximum before the twentieth year and gradually decreases after that time; being rapid from about the twentieth to the fiftieth year, averaging from eight to ten inches a year; being moderate from the fiftieth to the eightieth year, averaging six to eight inches a year in height; after that period being slow, not averaging over two to four inches in height-growth during each growing season.

The diameter-growth is slow until about the fifteenth to twentieth year and extremely rapid after that until the fortieth to fiftieth year, when it becomes considerably slower. These variations in the manner and rate of growth apply only to forest trees; that is, trees grown in large bodies with a thick stand, so as to fully shade the ground and crowd and overtop each other as soon as height-growth is fairly under way. While these laws of the rate of accretion, or increase in volume of wood, are deduced from the rate of growth of what is called old-field growth, where growth began simultaneously with all trees, they are probably applicable to isolated young pines appearing in a hardwood growth or to young pines springing up in a pine forest where the mature trees are thick. Entirely different laws, however, govern the rate of growth of isolated specimens, or where the young trees are far apart; in which cases from the start there is rapid diameter-growth and crown development at the expense of height-growth and clear, straight stems.

In the boxed trees which now constitute so large a part of the long-leaf pine forests, practically all of the merchantable timber having been boxed, the rate of growth is exceedingly slow, ten or twelve years being required for one inch in diameter to be gained, and the annual increase in height not being over one to two inches.

The long-leaf pine in the forest forms no appreciable quantity of wood between the first and sixth years, and very little between the sixth and fifteenth years. During the next thirty years it adds rapidly to its bulk, and then begins a gradual decrease in the volume of wood added, which decrease continues normally at a uniform rate until old age destroys the specimen.

VALUE OF DETERMINING THE RATE OF GROWTH.

While a small tree, ten to twelve inches in diameter and all sap-wood, serves admirably for the manufacture of resinous products, it is only after a very much longer period of growth that a tree reaches a size suitable for saw-logs. This period is dependent, of course, on the rapidity of growth, which varies some with difference of soil. If heart timber is desired, and this is the only kind which is in demand so far as the long-leaf pine is concerned, the time required for a forest crop to reach maturity, when the trees have attained a size large enough for applying them to all uses, is certainly not less than one hundred years. This pine is about twenty-five years old before the heart-wood begins to form, and after that time, speaking in a general way, a ring of heart-wood is formed internally for every ring of sap-wood added to the periphery. So that to estimate the time required for the growth of trees with the heart-wood of a specified diameter the twenty-five peripheral rings of sap-wood must be taken into account, as well as the decrease in the rate of diameter-growth after the fortieth or fiftieth year.

The accumulated wood in the long-leaf pine trees, which form the forests as they stand to-day, represents the results of not less than one hundred and fifty years of uninterrupted growth and probably more than one hundred and seventy-five years; that is, the trees range in age from one hundred to two hundred and fifty years, while all of the trees less than one hundred years old, or about two-thirds of the forest body, have been killed out by fires or prevented by them from developing.

SUMMARY.

The infrequency of the seeding of the long-leaf pine enables trees which seed more frequently to prepossess the ground. Its slow growth renders it more liable to be killed in the tender, seedling stage. Its seed as well as the roots are eaten by hogs. Its slender stem makes it more easily broken off during the sapling stage. It does not bear seed until five or six years later than the loblolly pine of the same age. In all stages of growth, on account of the thin bark, it is exceedingly sensitive to fire and heat, which, without burning them at all, frequently kill large trees. When a tree is but partially scorched the borers attack it and finally kill it. Vigorous trees between eighteen and thirty years old, which have a thick, firm bark, appear to be least injured by spring fires.

DESTRUCTION OF PINE TIMBER BY FOREST FIRES.

In spite of the hogs, if fires had been kept off of these long-leaf pine lands during the past sixty years, or since the extensive tapping for resin began (about 1835), the forest density would now probably be no less than it was before that period. The trees which are now being removed for lumber could still have been taken and with good results; for those left would have grown with renewed vigor as the thinning was carried on. It appears that at least one-half of the standing timber has been destroyed by fire and the loss to the people from this item alone has been immense. The low price of long-leaf pine lands is a source of constant dissatisfaction to its owners, while the truth of the matter is that at least one-half of the merchantable timber has been burnt off, and smaller trees which would have become merchantable timber have been prevented from doing so by the forest fires.

FOREST FIRES A CAUSE OF THE DECREASE IN NAVAL STORE PRODUCTS.

For the past eighteen years there has been a constant decrease in the output of naval store products in this State. This is directly due to the fact that the existing orchards are becoming exhausted. Since 1830 the fluctuations of the exports of resinous products from Wilmington have been indices of the prosperity of the industry in the entire State; so that to say that the exports of rosin from Wilmington fell from 700,000 barrels in 1870 to 450,000 barrels in 1880, to 385,000 in 1890, and to 200,000 in 1894, merely expresses the rate of the decline in production for the State. An examination of the lands of the pine belt completed in the spring of 1894 disclosed the fact that there were, at that time, only 55,000 acres of original growth long-leaf pine timber which had not been boxed; and only 33,000 acres of young growth long-leaf pine which had become trees, or which had reached a sufficient size to insure their becoming of commercial value; and some of this had already been tapped for turpentine. As has been stated before, this young growth lies almost entirely in what were at one time old fields, or enclosures by which it was protected from fires and hogs. Only in New Hanover county has any considerable amount of young growth been observed on forest lands; and there a law prohibiting stock from roaming at large through the forest lands has been in force for a number of years.

When the producer of turpentine burns his woods to keep them open and facilitate the collection of turpentine he fails to consider that all the young growth, from the youngest seedling to the mature stock, represents so much invested capital; and that the fully mature trees alone represent the accrued dividends, which ought to be so utilized as in no way to interfere with the great productive portion of the capital. In neglecting this the productive body has been destroyed as worthless, while the mature trees, which represented only one crop evolved from it, were held as the only prize.

However deleterious to the mature trees may be the system of collecting resin which is in use throughout the United States, its destructive results are insignificant as compared with those produced by using fire to keep down the "troublesome growth" of young pines. The entire forest reserve has been made subservient to the means used to lighten the labors of those engaged in the collection of these forests by-products.

THE EXHAUSTION OF THE LONG-LEAF PINE FORESTS.

The exhaustion of the long-leaf pine forests of this State may be looked for now at no distant date. The waning turpentine industry will hold its own, as an industry of some importance, possibly for ten years longer, though there will certainly be a steady decrease in its yield each year. The production has possibly been stimulated during the past two years by the fact that while the agricultural products of this section were depressed in price the prices for the better grades of resinous products have, on the whole, been more favorable and the demand firm. With a general rise in the prices of farm products the working of many turpentine orchards would probably be relinquished.

The long-leaf pine lumber industry has probably reached its maximum expansion in this State, and its decadence when once set in will be rapid. The largest bodies of compact forest are in the counties of Moore, northern Richmond and eastern Montgomery. These will last for ten years if the drain upon them continues at the present rate and there are no large fires; but there probably will be many fires. Two of the largest fires since 1890 have occurred in this district, consuming or damaging timber to the value of over $200,000.

INCREASE IN THE AREA OF WASTE LONG-LEAF PINE LANDS.

Including both the forest lands and the old fields and fallows, there are now at least 600,000 acres of waste or unproductive land. This area, as large as it is, may be expected to increase during the next decade to about 1,000,000 acres, as lumbering proceeds on the sand-hills, where no loblolly pine succeeds the long-leaf pine. About 75,000 acres of this sandy land are yearly denuded to furnish the output of 150,000,000 feet, board measure, of yellow pine lumber; and the greater part of the land, having served what is regarded as its final use, is left uncared for and kept, by the continual burnings, idle and unproductive, covered only with scrub oaks which withstand the fires.

THE NEED TO PROMPTLY STOP FIRING THE PINE BARRENS.

In 1892 there was an abundant and generally distributed long-leaf pine mast. The young seedlings from this were to be seen everywhere the next spring, but a large part of them have already been destroyed. Even on lands which have been lumbered, severely burnt or worked for turpentine for a long period and then abandoned a good many years ago, and which had only one or two mature old seed-bearing trees of long-leaf pine to the acre, there were in the spring of 1893, following this heavy long-leaf pine mast, hundreds of young seedlings to be seen scattered among the young scrub oaks or beneath the old ones. Given half a chance and they would all have grown. Many of them are still left; and no greater benefit could be conferred upon the south-eastern section of this State than to have these pines protected, and allow them to grow.

Although these south-eastern counties have for so long supplied such a large amount of high-grade timber, it is nevertheless a fact that in many places good timber, for domestic uses, is becoming scarce. With all the timber being cut for shipment and none reserved for home use in the future, and all the young growth which would in time make timber being killed by the fires, there is no reserve timber which can be relied upon to meet the demands even of the next few decades. If these young pines are all killed out, it means just so much loss to the people; and it is the people, individually and as a body, who should take steps to prevent this result. No effort should be spared by them to protect the young seedlings where any are yet to be found and to see that they are enabled to grow into mature trees.

It is only by so doing that the timber supply of this region, even in the near future, can be made a certainty. It will probably be many years before there will again be a mast of the long-leaf pine equaling the recent one, either in distribution or in abundance, and in the meanwhile a large number of the seed-bearing trees in large bodies, or the stunted trees left in lumbering, or the scattered trees in the turpentine orchard, will have been destroyed, so that neither the aggregate number of the young seedlings nor the uniform thickness of the stand can possibly be so great again in the near future as at the present time. It is no more difficult to give the necessary protection now than it would be at a future date, while the benefits derived from prompt action and careful watching will now be manifold. No one, who has at all investigated the situation, will deny that the young long-leaf pine growth must at some time be afforded protection, if there is ever to be a regrowth of lumber trees in this section on the sandy soils.

EFFECTS OF BURNING ON PINES, CYPRESS, CEDARS AND BALSAMS.

The effects of fires on the long-leaf pine seedling have already been stated. One and two-year-old loblolly and short-leaf pines will sometimes shoot from the roots if burnt down; and these trees by reason of their rapid growth and thick bark are little injured by ordinary fires after they have reached a height of fifteen feet and a diameter of four inches; the large trees of both of these species have thick and close barks. The pocosin pine, like the pitch pine (the black pine of the piedmont counties), has remarkable recuperative powers, young seedlings when burnt down for several consecutive years still continuing to sprout from the stump or roots, and fair-sized saplings when killed above put up root sprouts. These root sprouts, however, do not make large or vigorous trees. White pine seedlings growing on dry ridges with oaks are very tender and do not put up again after being killed down.

Cypress swamps, even in very dry seasons, are rarely burnt over, and although when this happens the damage to large trees is usually small that to the younger trees and shrubs is considerable. Small cypress, however, if under three inches in diameter, will frequently sprout from the stump. Neither red cedar nor white cedar (juniper) probably sprout again after having been burnt down. Oaks or pines often take the place of a growth of red cedar; and the white and sweet bays and gums will take the place of a growth of white cedar if the soil is not too peaty for their growth. The forests of black spruce and Carolina balsam along the summits of the highest mountains are sometimes burned. The seedlings of neither species sprout again. A growth of wild red cherry (peruvian) mixed with some black cherry and yellow birch forms the aftergrowth, which is in time supplanted by the spruce and firs again. The hemlock-spruce (spruce-pine), owing to the damp places of its growth, is rarely injured by fire. Neither it, however, nor the Carolina hemlock sprout from the stump or roots after the stems have been cut or burnt.

BROAD–LEAVED OR DECIDUOUS–LEAVED TREES.

The oaks vary a great deal in their behavior after a fire. Nearly all of them, if young and vigorous, will sprout from the roots after the top has been injured. While this is true, their sprouts, like those of most other trees under similar conditions, are never certain to make large or sound trees. As the dead stock decays an opening or scar is apt to be left at the foot of the tree, in which rot is almost certain to begin sooner or later. This seems to be more certain in the case of black and red oaks than in the case of white oaks, which latter, it seems, are attacked by fewer rot-causing diseases than the red oaks.

But few of the oaks sucker if the burning is repeated many times in succession. While the trees from shoots are usually unsound, those from suckers are decidedly short-lived and are much affected by drought, owing to the fact that their root systems are superficial and they have no tap-roots or deep-seated lateral roots. This is well known to be the case with apple stock in which the grafts have been made on suckers instead of upon seedlings. The oaks which sucker most seem to grow on sandy or light soils; the live oak, the laurel-leaved oak, sometimes the post oak and sometimes the high-ground willow oak and the water oak. Young trees of the Spanish, black and scrub oaks are capable of withstanding a fire which would kill outright equal-sized trees of the white and, probably, of the post oaks. Some of these trees, as the black-jack, seem to be, as far as an ordinary leaf or brush fire is concerned, nearly fire-proof. Sapling red oaks, too, in the higher mountains are very hardy.

While all of the hickories and the white and black walnuts are extremely sensitive towards fire, they all sprout more or less from the root or collar when young. Some of them, as the white hickory, will even sprout, when six to eight inches in diameter, if killed down in the early spring when the sap is rising, though if killed later in summer they will not sprout at all. The birches all sprout, some from the roots, while sapling beeches if top-killed will frequently sucker besides. Young sour-wood trees sprout freely if killed down. Black gums are hardy and even when young are not much injured; but while sweet gums are more injured they put up vigorous root shoots. The Ailianthus ("tree of heaven"), which has in many places made itself at home in the woods, and which affords a valuable timber, suckers so as to form dense thickets of young shoots, even when trees twelve to eighteen inches in diameter are top-killed by fire; and especially is this so if the trees are in the open or under a light cover. The white bay in the lower district suckers from the constant burning, so as to form dense clumps five to ten yards in diameter of low, scrubby trees; and in places, but more rarely, the same is true of the yellow locust in the mountains. The chestnut is one of the few useful trees, which is not only fairly hardy, but also when killed down sprouts vigorously and abundantly, and its sprouts reach a large size. But even it cannot continually propagate itself in this manner, and unless the woods are renewed by seedlings with fresh life and vigorous roots the chestnut, too, will begin to become scarce.

All of the trees which are especially worthy of protection, on account of their economic value, are greatly injured by fires. But some of the most valuable hardwoods, as the white oak, hickories, chestnut and locust, succeed in securing a stand after light fires.

Leaf fires in the late spring burn up the seed of the elms, as they ripen and drop their seed in March and April. Fires during the winter and early spring are apt to destroy the germinating powers of most seed then on the ground. The seed of several of the hickories, the more valuable ones, the walnuts, the buckeye and some of the oaks can resist considerable heat. A few trees, such as the soft maples and the box elder, ripen their seed in summer and as they sprout at once there is no chance for them to be destroyed before at least making a start. The scorching leaf fire, though, destroys thousands of seed in every acre of woodland through which it passes.

EFFECT OF BURNING AS SEEN IN THE COMPOSITION OF THE FOREST.

If the fires are merely leaf-fires, as are most of the fires in the hill country of this State, but are regularly repeated, the seedlings of tender kinds are kept killed down, while those of kinds which do not sprout from the root are killed outright. This in the end, after repeated burnings, will make the forest composed almost entirely of trees which sprout from the stump or roots, and only the hardiest of these will survive, no matter whether they may be valuable or worthless. This is seen in the way the hardier oak growth has taken the place of the pines in many places in the eastern section of the State; for when protected from fires, as in old fields and in enclosures, the aftergrowth is almost of unmixed pines.

In the middle section the hardier black and black-jack oaks are taking the place of the hickories and, in places, of the white and post oaks, while the young growth of the tulip poplar has entirely disappeared from over certain areas, or is confined to the moist lands along streams. In the upper districts the sourwood, from its rapid growth and readiness of sprouting, has become exceedingly abundant, to the exclusion of more valuable trees. In the lower mountains the scarlet and black oaks have been enabled to greatly increase their numbers from their hardiness, while at higher elevations, where the chestnut is common, there are found groves of open chestnut woods, the trees short-bodied and broad-crowned, where there was at one time a mixed forest of red and chestnut oaks, and other trees. Here the chestnut, from its power of producing vigorous shoots, has alone been able to maintain itself, while other trees, which are accounted unusually hardy, have largely succumbed. Such groves are not infrequent, on southern slopes, through the forests of the Appalachian plateau, between 2,500 and 4,500 feet elevation. Few young trees are to be seen anywhere among the chestnuts. The red and chestnut oaks and the chestnut are the most common trees on southern hill-sides and slopes in the higher mountains. Everywhere they are seen in varying proportions, according as they have been injured by fire, in which case the chestnuts outnumber the other species; or the nuts eaten by hogs, when the young red oaks become the more numerous, since the fastidious hog prefers the sweet nuts of the chestnut and the chestnut oak to the bitter acorn of the red oak. But slight damage is wrought by fire to the forests of the higher mountains on northern slopes, owing to their openness, the dampness of their humus, and their never having been lumbered or extensively culled, and hence not being encumbered with lops or thickets which would furnish fuel for fires.

FIRES CAUSE DECAY AND HOLLOWS AT BASES OF FOREST TREES.

The greater number of the hollow, immature and undersized chestnuts, yellow poplars and oaks in the middle and western counties were formed either directly or indirectly through fires. Fires scorch small spots near the bases of trees, which cause the death of the liber or generative tissue from which the tree increases in diameter. The bark then becomes loosened, or falls off, over the spot, and the tree presents on its surface a layer of dead sap-wood. The sap-wood of most trees is, as is well known, more subject to the attacks of insects, borers, beetles, etc., and to rot than is their heart-wood. If the bark is merely loosened insects will quickly enter the spot, and will channel sometimes into the heart-wood. Through their openings air and water afterwards enter, leaving the germs of decay. In this way the entire interior of the base of a tree may be made hollow and, the bark remaining intact, exhibit no signs of the rottenness which is within.

If the bark falls off immediately from the burning the dead sap-wood is then directly exposed to rot, and fungi in the shape of punk, or mushroom-like excrescences, grow upon it. These and their representatives in lower and more obscure forms are the causes of rot. Their roots, as their vegetative parts may here be called, in the shape of minute white threads, penetrate the dead wood, at first the dead sap-wood and then the heart, and break down the structure of the wood, so that finally great hollows are left. Successive fires, too, will gradually eat into the dry and deadened wood, and not only burn out the heart-wood but consume the walls of sap-wood. The base of the stock is finally greatly weakened, and storms prostrate thousands of such specimens whose stems above the hollow buts are perfectly sound. Or if they stand, the rot and the fire will gradually destroy so large a portion of the cylinder of heart-wood that the value of the tree for lumber will be greatly lessened. All such, however, will finally windfall.

EFFECTS OF BURNING ON THE SOILS OF FORESTS.

Burnings probably produce few changes in the inorganic parts of soil; at least, such as may be produced, are unimportant. But all the organic ingredients which lay on the surface are destroyed; and peaty soils, which have a large proportion of inorganic material intermixed throughout their whole structure, are often seriously damaged by having this organic matter consumed so as to have their industrial value lessened or destroyed.

HUMUS AND ITS FUNCTIONS.

One of the most important requirements of forest growth is the humus, which is the accumulation beneath the trees of fresh and decaying organic matter, mostly shed by the trees themselves in the shape of leaves, or by the undergrowth beneath the trees.

While humus, of course, cannot take the place of inorganic soil, it largely supplements it in its chemical relations, and besides performs important physical functions in connection with tree life. Its depth and richness depend to some extent on the character of the soil and the kind of growth which it supports. It is deeper usually under broad-leaved trees than under conifers, and under trees like beach and maple than under oaks.

For the trees of North Carolina its depth and the rapidity of its accumulation are almost directly dependent upon the shade-bearing power of the trees producing it. There are a few exceptions to this, as the black spruce, which, though shade-enduring, forms only a poor humus, and the tulip poplar, which, though light-enduring, forms a humus of good quality.

Humus a Resevoir for Water.—Humus is exceedingly hydroscopic. The interfibrous capillary meshes and net-work absorb water, or even moisture, with the readiness of a sponge. During a rain it imbibes water until saturated, which adds greatly to its value on hill-sides, where, if the ground were naked, all the water which fell, and which the soil did not at once absorb, would drain off superficially. In the humus, or mold, it is stored away and gradually given up to the soil beneath, as that becomes drier through evaporation from the trees or through subsoil drainage. The importance of preserving this humus is seen, too, in the fact that it equalizes the flow of water in our rivers and streams, and, besides holding in check the great freshets, enables more water to be utilized in dry seasons by the hundreds of cotton, woolen and grist mills in the State which depend upon water for their motive power.

The evaporation from compact humus is less than from soil in similar situations, since the heat-conducting power of humus is less. Every agriculturist realizes the value of this fact, and utilizes forest litter as a mulch for retaining moisture in the soil. To the sylviculturist, or grower of trees, this property of humus is of especial importance. One of the paramount requisites for tree growth is moisture. Indeed, next to the physical properties of soil none other of its qualities seems to be more influential in determining the character of the forest growth than the proportion of moisture present.

Another property of humus mentioned above is that it is a poor conductor of heat. For this reason it is affected by sudden thermal changes less readily than drier soil is. The value of humus to woodland in this relation was fully exemplified during the spring of 1894, at the time of the sudden and late frost. The severe frost of April, besides destroying the foliage and nuts of all white hickories, which are the most abundant and valuable hickories in the middle district of North Carolina, killed hundreds of these trees. The trees killed stood on southern hill-sides or crests, where the ground was open and there was no humus, and these trees had partially leaved out; while no or only slight injury was done to other hickories of the same kind which were situated with like aspect but in thick growth, and with a good humus around them, and whose buds consequently, being less effected by the spring warmth, had not yet exfoliated. This method of mulching with humus to delay foliation or florescence, as a safeguard against late frosts, is artificially practiced by orchardists, especially peach growers. The hickories killed by this freeze were almost entirely mature trees, the young ones being more usually found where there is considerable undergrowth, and consequently some humus.

THE BENEFICIAL CHANGES HUMUS UNDERGOES.—The chemical properties of humus are regarded by agricultural chemists as being of the first importance in farming, and they lose none of their value by transference to the forest. The chemical elements found in forest humus are, of course, those necessary for the building of trees, since the humus is directly derived from this source. The natural changes which this humus undergoes are such as are most beneficial for the growth of the surrounding forest, and show the power of organic life to husband its resources and render available for its own nutrition the products derived from the disorganization of its own wastes.

Humus, by its decay, forms organic acids, and these in turn form salts by combining with the mineral bases, potash, lime, soda and magnesia, which exist as such in the leaf tissues. These salts, like the humus itself, are only slightly soluble in water, and this prevents them from being entirely washed out by drainage, and their usefulness, as far as the soil of that locality is concerned, being forever lost.

Sooner or later, however, these compounds undergo another change, combining with stronger acids of the soil, when their fixation is complete, and they return to the original or similar compounds from which they were primarily derived by plant life.

Ammonia, or nitrogen, in the form of compounds available to the living plant, is one of the expensive constituents of many commercial fertilizers, and is one of the bases of their value. The nitrogenous waste from humus is in the form of ammonia combined with some of the plant acids, or other organic compounds, or with part or all of these compounds replaced by a mineral acid. Finally most of it becomes fixed in the soil as nitrates of alkalies, lime, magnesia, potash or soda. In this manner the valuable nitrogen is again brought back to the soil to enter into the formation of plants.

EFFECTS OF FIRES ON HUMUS.

Fires interrupt this process, which nature has perfected for conserving its energy. They consume all that part of the humus which lies upon the surface of the earth. But they produce changes of more consequence than mere interruption. By the burning the humus is reduced to ash, while the volatile parts and the gases of the combustion pass off as smoke. There are included in these gases of the smoke the carbon or charcoal part of the humus, and other elements, which would have yielded, in connection with this, organic or earthy acids, had decay continued under normal conditions. The most valuable compound, which is in this way destroyed, is the ammonia, or nitrogenous part of the humus. The heat volatilizes this, or sets it free from the complex bodies of which it formed a part, and it is dissipated in the air.

All that the fire leaves is a small quantity of lose ashes. The first wind that comes can blow it entirely away, so far as that locality is concerned. Although they look alike the ash from the pines and from the broad-leaved or deciduous-leaved trees differ much in the proportion of the different alkalies and other compounds of which they are formed. That from the pine contains more of the alkaline ingredients that are soluble in water, almost one-half of their weight being thus soluble, while only about one-sixth of the weight of ordinary hardwood ash can be dissolved in water. If the country is at all hilly the water of the first heavy rain that falls, since it now has no humus to hold it in check, will bear off all the soluble portion of the ash.

A great part of the insoluble ash will in like manner be washed away—if the country is steep and the rain heavy, practically all of it, since, being light and loose, it does not offer the resistance that compact earth does. The soluble parts are decidedly the most valuable. In both pine and hardwood ashes they consist chiefly of sulphuric acid, potash and soda, while the insoluble parts are largely lime, iron and sand in pine ash, and lime with small quantities of magnesia and phosphoric acid in those from hardwoods.

This burning thus robs the burnt lands of their available mineral salts, on which fertility is so largely dependent. If persisted in it eventually greatly lessens the productive power of even the best of soils, especially in hilly or mountainous districts.

It is fortunate that the pine forests of North Carolina, in which so much burning is practiced, grow for the most part in plains and upon sandy or gravelly soils, which allow ready percolation by the rain water and afford quick fixation of the alkaline and other parts of the ash. By this fixation the soluble part of the ash — and, as has been said, over 50 per cent. of pine-wood ash is soluble — is made less soluble, so that drainage water will not bear it off. This fixation may or may not affect its availability, so far as the plant is concerned. About that, as yet, very little is known.

PEATY SOILS.

Moreover, there are soils which are largely made up of humus. There are peaty or highly organic soils chiefly in the north-eastern section of the State, around the Dismal swamp, in Hyde and Dare counties, and areas of smaller extent but similar in character in Pamlico, Lenoir, Duplin and Bladen counties. These soils are either those which from intermixture of sand and their capability of being drained are suitable for tillage. or those which "sour" and are usually too low for complete drainage. The first kind frequently rests on a bed of green sand or marl, and before cleared—for such land is now largely cleared—was covered with cypress, gums and tulip poplars; much of it, too, was once lakes that have filled in with *detritus*; while the second kind, which is "sour," bears a growth of white cedar (juniper) or white bay and has usually passed through the successive stages of a sphagnum bog before reaching its present condition.

The sour or peaty lands can be put to no more profitable use than growing white cedar; keep the fires out, protect the young growth of white cedar and keep it as nearly pure as possible. It is decidedly the most valuable tree of eastern North Carolina; besides being an abundant seeder and of rapid growth it is exceedingly hardy. It is a yearly event, however, to hear of a fire, often originating from carelessness, passing through one of these swamps and consuming not only the trees both great and small, but frequently burning out the soil until its level is so lowered that white cedar will no longer grow upon it. There are thousands of acres of timbered swamp lands which have been ruined in this way in the Dismal swamp and in such counties as Dare and Hyde: and it frequently happens that peaty lands, even while under cultivation, are burned out and greatly injured.

DAMAGE TO THE STATE LANDS BY FIRES.

The State Board of Education controls for the educational fund of North Carolina a large amount of swamp lands in eastern North Carolina. Although some of it is heavily timbered much of it shows to the fullest extent the ravages of fire. Some of this swamp land which remains unsold has naturally a poor, compact soil, and is incapable of sustaining any but an open and scrubby forest growth. Some of it, however, which is now largely covered with cane-brakes, shows conclusively that it was at one time heavily timbered, probably with gums, poplar, oak, and cypress, and that innumerable fires have kept the trees killed down while the cane has spread until now the timber on the lands is perfectly worthless. Considerable areas of these State swamp lands, being regarded as belonging to no one in particular but to the public in general, have been robbed of their valuable timber, and are now annually fired for the purpose of improving the grazing advantages they may offer for the neighborhood herds of cattle. In this way not only has the land been robbed of its supply of mature timber, but the young forest growth also has been destroyed, and thus the future timber supply cut off in large measure.

AREA OF WASTE LANDS IN NORTH CAROLINA.

The census of 1880 gave some interesting and significant figures upon the proportion of the area of this State in woodland, in cultivation, and "other lands," which are idle or unproductive. The amount of this idle or waste land given at that date for North Carolina was 2,000,000 acres, or one-tenth of the entire area of the State was lying out as old fields or other waste lands. An investigation of the forest lands of the eastern counties, undertaken during 1893-1894 by the Survey, showed that there were in the long-leaf pine counties alone, those counties lying south of the Neuse river and east of Montgomery county, over 400,000 acres of sandy forest lands which were producing no valuable forest growth, and under the present negligent management are not likely in the future to do so. This is partly land which, after being lumbered, has been burnt over, or the tree growth, by the many repeated burnings, has gradually been reduced from long-leaf pine forests to scrub-oak thickets, with still a few scattered pines upon it.

The area of the waste lands in other sections of the State has certainly increased considerably in the past fifteen years, so that it can be no exaggeration — in fact, it is a decidedly small estimate — to say that there are now in North Carolina over 3,000,000 acres of waste or unproductive land, including old fields, bramble lands, and forest lands with only a growth of scrub oaks. This makes about one-eighth of the entire area of the State which is at the present time unproductive, either of farm crops or forest products.

AREA OF WASTE LANDS IN EASTERN NORTH CAROLINA.

In the eastern counties, with sandy or sandy-loam soils, and lying within the coastal plain region, the area of the waste land in forty-two counties amounts to over one million acres, or to one-tenth of the total area of those counties. Except the pine barren lands which have already been discussed, any of these lands would be quickly and thickly seeded by the valuable loblolly (short-leaf) pine, and would soon be covered with a heavy young growth of these pines if the fires were kept off. Where the loblolly pine has been lumbered small post and red oaks usually come up. This should be discouraged, as the pine growth is the more valuable of the two. The cause of the oaks appearing is that the young oaks, being able to bear a light shade, are usually found growing under the pines, and if, as usually happens, a leaf-fire passes through the woods after the merchantable pine has been cut, the young pines which come up with the oaks are killed, so that the oaks alone remain. In this section considerably over half of the area is yet woodland, though a great part of it has been lumbered.

AREA OF WASTE LANDS IN THE MIDDLE AND WESTERN COUNTIES.

In the midland counties, which extend westward as far as the foot of the Blue Ridge and eastward to the sandy soils of the low district, the area of the waste lands amounted, according to the

United States Census of 1880, to over 1,500,000 acres, or between one-fifth and one-sixth of the total area. Only a little over one-half of the area of this district is now in woodland. The waste land consists very largely of old fields, many of which have upon them so heavy a sod of broom-grass that it is impossible for a young seedling to gain a foot-hold. Some of these grass lands in the early spring, when the young grass is coming up, after the old has been burnt off, give a scanty pasturage for a few cattle. A large part of the area is typical red clay old fields, washed and gullied, with a poor sod or none, and brambles, persimmon trees and sassafras scattered along the fence rows.

In the mountain counties, except in a few localities, around some of the larger towns and in long settled communities there is very little waste land. In some places, however, there are steep hill-sides which it has been found unprofitable to cultivate, and on which no turf has formed. These consequently have badly washed and gullied. Turf forms on the clayey soils from the slaty rocks less readily than on soils, in similar situations, from the gneissic rocks and schists, and there is, therefore, more washing and gullying of the land on the first mentioned soils. There was in 1880 only one-twentieth of the land in these mountain counties lying out as waste land, neither in fields, pasture nor woodland.

YOUNG GROWTH ON WASTE LANDS.

With the farms scattered as they are through the forests, and surrounded on all sides by numerous kinds of trees it would be almost impossible for a year to pass without the seed from some forest tree being scattered on the numerous old fields and other tracks of outlying, waste or unproductive lands.

Young trees in fact do appear, pines chiefly in the lower division of the State, oaks mixed with pines in the midland division; pines, oaks, tulip-poplar, birches and maples in the mountains, according to the situation. What alone prevents the young trees from growing on the lands are the recurring fires. It makes little difference where situated the waste lands which are connected with farms are almost certain to be broom-grass fields. The burning of this grass, thick and three to four feet high, as it grows, will kill outright the most vigorous young trees four or five feet high or higher. After the grass has been in possession a good many years it forms a sod or turf, if such it can be called, which effectually chokes out the young seedling of all except the hardiest species.

CHANGES IN THE FOREST BODY.

While the changes which our forests are undergoing are gradual they are certainly effective; and the vicissitudes which we know have been occasioned elsewhere by such degenerative changes in the composition of the forest body are none the less sure because slowly produced. These particular changes which are now taking place must be passed through, at least to a certain extent, that we may realize them and take due precaution against their continuance or repetition.

Happily for us the waste of our forests and their alterations have been produced by ourselves in the attempt to satisfy our own needs. Our timber production up to the past decade has been almost entirely for domestic consumption. Primarily a clearing was made for agricultural needs, then the timber was used for building our own houses, fencing our own lands and furnishing our growing demands as fuel. While it was used in such a way, and only the largest specimens culled for special purposes here and there, it was felt that the forests were practically inexhaustible.

INCREASE IN THE LUMBER INDUSTRY.

The past fifteen years, however, have marked grave results. Since 1880 the output of lumber in North Carolina has more than trebled; and the value of the capital engaged in manufacturing has increased from $1,740,000 as reported by the census of 1880 to over $6,000,000 at the present time. It can be said to mark the results of a decade, for far the greater part of the increase has taken place during the past five years. It began along and near the coast where abundant water-ways afforded cheapest transportation facilities for both logs to the mills and the finished material to the consumer; and the timber most in demand has been the hitherto neglected sap loblolly pine. Already this new industry has made deep inroads into the forests of that section. Not content with the so long despised "old-field" pine the swamps have been canalled to reach the cypress and white cedar (juniper). This increased production here is to compensate for the continually increasing shortage in the yield of white pine in the north-eastern States. In Michigan alone this shortage last year was more than the entire annual production of pine lumber in North Carolina amounts to at the present time.

Last year (1894) less than one-half of the seven or eight hundred million feet of lumber manufactured in this State was used here; and each year, as the demand for Southern lumber becomes stronger with the increased consumption and the exhaustion of the forests of the Northwest, a larger proportion of our manufactured product will be for shipment.

The utilization, on a commercial scale, of the hardwoods of this State has scarcely yet begun. Of the 800,000,000 feet of lumber manufactured in this State during 1894 not over 50,000,000 feet were of hardwoods, oaks, ash, walnut and cherry. In spite of the general existing industrial depression the year 1894 chronicled the investment of over $300,000 in the hardwood forests of western North Carolina by northern lumbermen, while there had been previously invested several times that amount. Cypress and yellow pine lands alone, to the extent of 111,000 acres and $346,000 valuation, were owned by Michigan millmen in 1890.

The next decade or two will witness the development of the hardwood industry until it reaches the present proportion of the pine industry; and far-sighted millmen, seeing what an important part the hardwoods of western North Carolina are to play in the lumber market, are attempting to secure them before their value becomes generally known and they increase in price.

Without going further into the future development of the lumber industry in North Carolina, and the markets to be supplied by it, the general facts relative to the extent of our own demands and uses, the yearly rate of accretion of our forests, and their capability of yielding the products, must not be lost sight of.

PRODUCTIVE CAPACITY OF NORTH CAROLINA FORESTS.

There are in North Carolina at the present time about 12,000,000 acres of land in productive forests. The average yield of this land per annum is only about fifty to fifty-five cubic feet of wood, or about three-fourths of a cord to the acre. In the mountains, in places, the yield is twice this amount, and on some of the more fertile sandy loams of the north-eastern counties it is eighty to ninety cubic feet per annum ; but the smaller annual increment from the greater part of the woodland largely reduces the average.

This small yield is due to the woods being kept open, or non-productive, by the frequent burnings, and, in the hardwood forests, by the continual presence of cattle, which keep certain kinds of young growth eaten down; and of hogs, which never give the seed of other kinds even an opportunity of germinating. A great part of the land in the eastern section of the State is kept open by these agencies, so as to produce only scattering and short-bodied trees.

Some of the second growth woodland in the middle district suffers severely from the same causes, but not so much as in the eastern section, and in many parts of the mountains, especially those parts where cattle and sheep-raising are leading occupations, the woods are severely injured by both stock and fires. The harm that is being done in the mountains is as yet scarcely noticeable, as in most sections the mature forest still stands unbroken by the axe. But wherever there is a particular kind of tender growth it is noticeable that there is, even in the finest forests, no young growth ready to take the place of the mature trees on their removal. Everywhere destruction is pressing, and nowhere do the natural forces of growth prevail unchecked.

The average yield per year in this State should be not less than sixty-five to seventy cubic feet of timber to the acre, and the best quality of timber at that. With climate as equable as this, and a rain-fall abundant and evenly distributed throughout the year, there are encountered none of the natural drawbacks to forest growth which sylviculturists must so often contend with. The soils, too, are good, and well adapted to tree-growing; there is but little land rocky, or excessively dry, most of it, in fact, being deep and well drained.

If the three million and more acres of idle and waste lands be considered in this connection as forest lands, and much of it really is such, the average annual increment is reduced much lower than is given above. Taking the annual increment on the basis of fifty to sixty cubic feet to the acre, the total yearly yield of our forests will only amount to about 792,000,000 cubic feet, or 9,000,000 cords of wood, while there was taken from the forests in various ways during the year 1894 not less than 975,000,000 cubic feet, or 10,600,000 cords of wood.

There is, then, a great deal more wood being yearly taken from the forests in North Carolina than the yearly growth replaces.

CONSUMPTION OF WOOD IN NORTH CAROLINA.

By far the larger part of the wood used in this State is for domestic fuel. In the consumption of wood for fuel North Carolina ranked, according to the census of 1880, as the fifth State; 7,500,000 cords being used for that purpose alone in 1879 by the people of this State. This is equal to five and one-half cords per head for every person in the State. The value of the wood used for fuel that year was $9,500,000. The consumption has probably greatly increased since then, as the population has increased over 300,000; it certainly has not decreased, and is not likely to do so, as wood is not only the fuel for the entire rural population, but is the chief fuel used in all the towns, and in manufactures of all kinds and by many of the railroads now in operation. The general quality of the wood thus utilized is on the whole low, but in the south-eastern counties some of the finest pine is being used in this way and the same may be said for young hickory in the midland counties.

Material for construction makes the next largest inroads into the forest. There were at least 200,000,000 cubic feet of wood thus used last year, including lumber, shingles, hewn timber, railroad ties, telegraph poles, etc., and taking into consideration the tops that are left unused in the woods; while there was half as much more used for rail-fencing, fuel for manufacturing and destroyed by fire. Even this does not represent the entire amount of wood that this State furnished, for many million feet of round timber, mostly tulip-poplar, white pine, ash and hemlock-spruce, were sent to mills in east Tennessee by way of the rivers flowing westward out of this State; while 250,000,000 to 300,000,000 feet, board measure, of pine and white cedar logs were exported from the north-eastern counties to mills in the adjacent parts of Virginia and were there manufactured. Moreover, there were exported from this State over 400,000,000 feet, board measure, of manufactured lumber, besides square timber, railroad ties, posts, etc., in smaller quantities.

VALUE OF THE ANNUAL WOOD PRODUCTION IN NORTH CAROLINA.

While the single item of fuel is decidedly the most important of any forest product, both in value and quantity, it represents less than one-half of the entire aggregate, including both crude timber and the manufactured product in North Carolina. The value of the crude timber produced in the State during the past year was about as follows:

Value of fuel, domestic and for manufacturing	$10,000,000
Value of saw-logs at mills	3,500,000
Value of round timber, exported	1,000,000
Value of railroad ties and hewn timber of all kinds,	500,000
Value of all split fencing, posts, etc	500,000
Total value of all crude products	$15,500,000

If the value of the manufactured products, including by-products like naval stores, tan barks, various oils and extractives, be included, the total value of the forest products of this State will certainly not be less than $22,000,000 and probably will reach as high as $25,000,000.

The largest items under the head of manufactured forest products are:

Manufactured lumber of all kinds	$7,300,000
Special industries, veneers and woodenware	300,000
Cooperage	125,000
Paper mill products (from pulp), estimated	100,000
Resinous products (naval stores, etc.)	1,750,000
Tan barks and extracts	45,000
Wagon, buggy and car factories	600,000
Furniture and repair shops	200,000
Oil of wintergreen	30,000
Packing boxes, undertaking caskets and agricultural implement manufactories	85,000
Total	$10,535,000

If the items which are counted twice be taken from this amount and the value of the crude timber which is not manufactured be added, it will give nearly $23,000,000 as the value of the forest products of North Carolina, and this does not include the great item of building and construction, and several minor items.

This makes the forest crop decidedly one of the most valuable in the State. It is nearly equal in value to the corn crop, and exceeds the combined value of all other grains. It greatly exceeds in value the united products of all the floricultural and horticultural interests.

THE PERIOD REQUIRED FOR FOREST ROTATION.

At first glance it seems paradoxical to state that the yearly production or accretion of our forests is less than 9,000,000 cords, while these same forests are now furnishing over 11,000,000 cords of wood per year. As a matter of fact, the growth which is now being cut up in a decade or two represents the accumulation by the united energies of nature of several hundred years. The only way to ascertain the length of time it requires a forest to reproduce itself is to determine the period required for the individual trees which compose it to reach their maximum age and size.

The loblolly pine (short-leaf or old-field pine of the eastern counties) is under favorable conditions one of the most rapid growing trees. Even it requires fifty to sixty years for the old-field growth, where the soil has been cultivated and enriched, to become large enough for saw-logs with a diameter of about two feet; while the ordinary swamp or rosemary pine growth, which furnishes so much of the timber, represents a growth of over a century. The cypress, which are exceedingly slow growing trees, required two or three times as long to reach their present proportions. Long-leaf pines sixteen and twenty inches in diameter are between one hundred and twenty-five, and two hundred and fifty years old. The mixed pine and hardwood forests of the midland counties represent in their virgin condition from one hundred to one hundred and fifty years' growth; while it will require from two hundred to three hundred years to replace the forests of the mountains when they are destroyed.

Taking the figures of the census* of 1880 as a basis, and these figures are doubtless sufficiently correct, about that year the relation between our wooded area, the rate of accretion, and the rate of consumption from, or rather the rate of depletion of our forests, was such that consumption just about equalled the total accretion of that year. Each year after the occurrence of this state of equilibrium there has been a more decided change in the relation of total accretion to consumption; for not only has the forest area been constantly lessening by the encroachment of arable lands, which decreased the productive possibilities, but there has been a constantly accelerating increase in demand as population increased and wants multiplied. We have now reached a situation where depletion largely exceeds accretion.

It is evident that it is from no lack of woodland, for over one-half of the total area of the State is still in trees. Some change, therefore, must be made if the forests are to continue to supply our at present extravagant needs.

FOREST AREA OF NORTH CAROLINA AND ELSEWHERE.

While it has very little bearing on the present subject it may not be inappropriate to give the proportion of the area under forest in some of the principal countries of the world. European Russia has 46 per cent. of its area in woodland, which is about the same proportion which is in this State. Austria has about 32 per cent. of its area in forests. There is 26 per cent. of the German Empire in forests, and these are so well managed that they supply the needs of nearly the entire German people. Systematic forest management and protection of woodland is of long standing in Germany, and the knowledge and experience thus gained has been disseminated throughout all Europe, and is now being utilized in conserving and increasing the efficiency of the forests, not only of the most advanced European countries, but also of India, South Africa and Australia.

In France the system of Germany has been adopted, but with such alterations as best suited local conditions; and by its application the people are largely enabled to supply their own wood with only 16 per cent. of the total area in forest. In spite of the natural economy of the people of France, and the fact that other materials than wood are extensively used as fuel, considerable amounts of building timber are yearly imported. The forest area, however, is now being extended by the planting of new forests. The amount to which coal is used for fuel, and brick or stone for building materials, affects more than any other factors the amount of wood required *per capita.* Omitting the area west of the Blue Ridge, which is at present heavily timbered, but forms only a small part—less than one-seventh—of the aggregate area of the State, the wooded portion of the remaining part is less than one-half of the total area. Practically all the fuel used in North Carolina is wood, while in the entire eastern section of the State wood is the only building material available.

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*These figures will do for comparison, but for actual calculation the rate of accretion should be considerably smaller, and at the same time the rate of depletion larger, which would make this period of neutrality antedate the year given at least a decade, or about 1870.

PERMANENCY OF FORESTS.

That one cannot hope to see a young growth reach maturity and become merchantable sized saw-logs in a few months or a few years should not deter him from properly protecting and encouraging woodland growth. In forests which have been partly culled, as most of those of this State have been, and where there are many trees mature or nearing maturity, a thicket of young growth beneath the higher trees serves an important function in shading the ground, aiding in the retention of moisture and thus stimulating the older trees into renewed activity, and especially is this true of oak woods. That tree-growth is most rapid when the woods are kept open is a saying seemingly based on fact, but erroneous in itself. The chief requisite in timber is length of bole and freedom from knots. This is secured only by means of a thick growth during what is called the height-growth period of the tree's life. It is under these conditions that the greatest yield to the acre takes place. Diameter-growth, which is frequently thought to represent total growth, is attained by full light conditions; but this thickening of the stem is easily secured after height is gotten, especially in the hardwood forests where culling is practiced, by the removal of either the highest trees or those slightly overtopped, as the individuality of the species may necessitate or economy demand.

Forest growth, both old and young, then, should be regarded as an integral part of the productive wealth of the country. It, however, can only yield returns commensurate with its value when the young growth is carefully protected from fire and the destructive attacks of cattle.

A forest is not a mine of wealth, nor does it represent a mine in any sense of the word. The wealth of a mine is incapable of increase or replenishment when once exhausted. More fittingly, a forest is considered a soil crop, as liable to external injury as any other soil crop, the merchantable trees representing the mature harvest, which should be removed in such a way as to not seriously interfere with the younger growth, which in time will also reach maturity if properly protected.

It must be considered as a permanent factor in wealth production and care taken to husband its resources and to favor in every practical way the growth of those kinds of trees which are now fully recognized as commercially important. Although the forests of other parts of this State have not heretofore been of industrial importance, the forests of the eastern section have during the past thirty years been playing such an important part in its commercial and industrial relations that this fact need not be here dwelt upon. It is sufficient to say that the value of the forest products manufactured in that section last year (1894), from the pines alone, amounted to over $7,000,000, and the very basis of the prosperity of most of the larger towns in that region is the trade in or manufactures of forest products.

The hardwood forests of the middle and western districts are only now beginning to have a general commercial value for their products. This once assured, and the forests then will be commercially as important as in the coast region, and their depletion will be brought about as speedily.

LOSSES FROM FOREST FIRES DURING 1894.

With a view of determining approximately the losses caused by forest fires in the State during 1894 the Geological Survey recently sent a number of circular-letters to persons living in the several counties, and the statements published below have been abstracted from the replies received. Many of the replies were so general or vague in their statements that they furnished no accurate *data*, even for local districts, merely stating that the "damage was large" or "forest fires common." In the middle district, where herds of improved cattle are coming to be kept and are more properly cared for, there are in many of the counties stock or no-fence laws, which restrain cattle from running at large through the woodland. This has caused the practice of burning the woods to be largely discontinued, and very few fires were reported at all from the midland counties. The most numerous and severe fires were in the southeastern counties, where the chief cause for burning was to secure pasturage for a few cattle. Other fires in this section were thought to have originated in efforts to protect turpentine orchards and to protect homes or crops from destruction by accidental fires. Only a few fires were reported as having been caused by the carelessness of railroad hands, or by sparks from locomotives.

SUMMARY OF REPORTS FROM COUNTIES.

Abstracts have been made of the reports received from each county, preserving in each case, where it was possible to do so, the words of the correspondents. The reports are based on answers received from about 250 letters and circulars sent to persons in eighty of the ninety-six counties. The sixteen omitted counties lay in the middle section of the State.

ALEXANDER COUNTY.—Only a few forest fires, and these of the kind that may be called leaf-fires, were reported from this county as having occurred during 1894.

ANSON COUNTY was almost exempt from forest fires during 1894. Besides numerous leaf-fires, a severe fire burnt or seriously damaged the timber on probably 200 acres of long-leaf pine land in the southern part of the county, occasioning only a nominal damage. The destruction of undergrowth among pines by fire is not considered a loss by the people, and in some places the burning of woodland is regarded by them as being rather beneficial than otherwise.

BERTIE COUNTY.—Numerous reports from this county state that while there were many small fires, mostly leaf-fires, the damage done to timber and fencing was not great; 3,000 to 6,000 acres were burned over, with a loss of $1,000 to $2,000. The origin of many of the fires was attributed to railroads. A great deal of young timber was destroyed.

BLADEN COUNTY suffered from a number of large fires during the spring months, burning over hundreds of acres with an almost total loss of timber. One report places the number of acres burned at 5,000, with a loss of $2,000; the largest fire being at the head of Colly creek, and burning 2,000 acres, with a loss of about $600. Firing the woods was intentional, and was done to get tender grass and to protect against unexpected fires in dry seasons.

BRUNSWICK COUNTY.—The fires in this county were for the most part grass-fires, which were set in the spring for pasturage. A large portion of the county was burned over; some turpentine timber was destroyed, though its loss did not amount to much. Firing the grass is commonly practiced. It has kept most of the pines killed down and already killed out a large part of the young crop of long-leaf pines, which resulted from the mast of 1892.

BUNCOMBE COUNTY.—Burning the woods has nearly ceased in this county, but is still to some extent practiced in the mountain districts, where cattle are grazed in the woods.

BURKE COUNTY.—There were 7,000 to 8,000 acres of timbered lands reported as burnt over in the South mountains alone, killing a large amount of pine timber and burning much fencing. Fires also occurred along the Blue Ridge and along the line of the Western North Carolina railroad, but did no great damage. All forest fires after the first of March kill much of the young forest growth. Fires were said to have originated from burning brush, o'possum hunters, and more frequently from incendiarism; those along the railroad from locomotives, and some were set by chestnut gatherers. One correspondent thinks that burning the dead herbage and undergrowth does good by killing insects; but sometimes it also kills yellow pines and growing timber. The benefit that may be done in the way of killing insects is doubtless insignificant as compared with the damage resulting from these forest fires in the way of killing out the young tree growth.

CALDWELL COUNTY.—One correspondent states that he knew of nine large fires; one in March in Lenoir township, one in March in Globe township, one in March in Patterson township, one in April in Yadkin Valley township, one in November in Patterson township, and another there in December; one in December in Yadkin Valley township, one in Lower Creek township and one in Kings Creek township. There were from 10,000 to 15,000 acres burned over, with a loss of about $5,000.

Another correspondent mentions seven fires in his section of Caldwell county during the year 1894. One of these was in June in Globe township, and in August and again in November in the same township. In November, in the central part of the county, near Lenoir, two fires occurred, one in Yadkin Valley township and another in Yadkin Valley and Patterson townships in December. There were about 40,000 acres burned over, with a damage to timber of about $6,000. Young poplars and chestnuts suffer most from these fires, but white pines are very much injured, oaks are scarred and often injured for lumber, as is also the case with chestnuts and hickories. These fires, this correspondent thinks, will cause the gradual disappearance of the chestnut. The trees are scorched by the fires and decay sets in on the burnt side. Fires are set in the woods to make the grass grow for cattle, and to burn the leaves so hogs can get mast. Wherever the stock-law has been introduced the number of fires has been much lessened.

CATAWBA COUNTY.—The damage to timber from forest fires in Catawba county, as in many of the other counties in the middle section of the State, was slight so far as could be learned. The timber in the county is largely of hardwoods, usually with hardwood undergrowth in the forests.

The damage to timber in MECKLENBURG, DAVIDSON, RANDOLPH, GUILFORD and PERSON counties was caused by occasional leaf-fires, and was on the whole not great.

CAMDEN COUNTY.—A forest fire on the "lake" side burned through to the swamp, near the Currituck county line. Over 2,000 acres were burned over, with a damage of $2,000 to timber and considerable damage to other property. One report states that a large fire usually occurs in this locality every year. There were several brush and leaf-fires in other parts of the county, which occasioned no more serious loss than the destruction of the young growth.

Columbus county.—Correspondents stated that burnings had occurred in numerous localities in this county, but they were unable to give the extent of the losses. One fire, burning over about 500 acres, occurred near Fair Bluff, and occasioned a loss of $125. It is said to have been due to the carelessness of railroad employees. Other and larger fires occurred in the north-western and western parts of the county, near Hub and Lennon's cross roads. The large turpentine forests of this county have been gradually destroyed by fires, which have also burnt the young growth down as fast as it has appeared.

Cumberland county.—A correspondent living in the eastern section of the county writes: "It is impossible even to approximate the number of forest fires occurring in this county. They take place mostly in the late fall, when their illumination is almost nightly seen and frequently at every point of the compass at the same time. The damage caused by them during the past year was very great, especially to old pines, and the area burned over large. The greater part of the young growth in the forest has been destroyed except the black-jacks, which in their green state are nearly fire-proof, and it is fortunate for the people of the sand-hills that it is so. Burning the woods is far too common, but is clandestinely done, as public sentiment decries it. It is done to stimulate early growth for worthless cattle."

Edgecombe county.—A correspondent writes that so far as he was able to judge, after consultation with others, more than two-thirds of the entire forest area of this county was burned over in February, March and April. Fires in the woods at other seasons occasion but little damage. The damage to the standing timber each year is from 5 to 10 per cent. of its value on the area burned over. When a forest is not burnt over in a number of years the damage then from fire is much greater. Losses from burning of fences amounted in 1894 to about $500. Fires are usually accidental from burning old fields and brush and hunting with torch. They have burned down most of the boxed pines and destroyed the young growth of timber.

On the basis above given 60,000 to 80,000 acres must have been burnt over, with a loss of $10,000 to $20,000.

GRAHAM COUNTY.—Burning the woods has been practiced in this and in Cherokee county ever since they were settled, and before that time the Indians practiced it. The trees in many places, especially the chestnuts, have been scorched on one side and then hollowed out from the effects of the fires. Much other timber and young growth is injured. Many of the mountains in Graham and Swain counties were burned over by the Indians during the past year. It is safe to say that one-fourth of the mountain lands of these three counties, Graham, Swain and Cherokee, was burnt over during the past year.

HALIFAX COUNTY.—A destructive fire occurred in March just west of Enfield, which burned over some 4,000 or 5,000 acres of timbered land. The damage, the correspondent thinks, would be at least $1.50 per acre, all undergrowth less than three inches in diameter being killed. Fires in the woods in this county are usually traceable to camp-fires, hunters and tramps. No reports were received from other sections of this county.

HARNETT COUNTY.—Leaf fires, or grass fires, set to better the pasturage, burned over a large part of the wooded area of the county lying south of Upper Little river. This part of the county has been burned over so many previous times that nearly all the timber on it has been destroyed. There were a few unimportant fires in the northern part of the county.

HENDERSON COUNTY.—One report states that a large part of the forest lands, at least one-third, was burned over during the winter of 1893–'94, between November and May, with a heavy loss of timber. The same report states that at least two-thirds of the standing timber has been damaged by fires which occur regularly each season, and which are purposely started to better the pasturage. Some fires, however, are accidental.

JACKSON COUNTY.—The outside mountain lands, or wild lands, are yearly burned over to supply grazing. At least a third of the area of these lands was estimated to have been burned during the past year. Great damage is done to the poplar and chestnut timber; indeed it is difficult to find in these wild lands a tree of these kinds that is not defective at the base from this cause.

JOHNSTON COUNTY, like the other counties in which the long-leaf pine predominates, yearly has a large part of its area burned over for the pasturage. Besides all the young pines being destroyed the damage to timber last year was estimated to amount to five per cent. of the value of the timber on the area burned over, and this was very little in excess of the usual annual loss.

JONES COUNTY.—Only a few local fires were reported from this county.

MACON COUNTY, like so many of the other mountain counties, yearly has a large part of the "wild lands" burned over. And although the fires are chiefly leaf-fires they have caused great damage to the timber. Between 10,000 and 20,000 acres were estimated to have been burned over during the past year. The loss from the fencing destroyed was placed at more than $2,000.

MADISON COUNTY.—Although there were several fires at various places in the county there was only a single destructive one reported, which burned over about fifty acres. Burning the woods is practiced in many sections of the county to keep the woods open and better the grazing.

MITCHELL COUNTY.—Thousands of acres, mostly on southern slopes, were reported as burned over during the past year in this county. One correspondent says that although the damage to standing timber from a single fire appears to be small the continual burning, year after year, results in serious damage, killing much of the timber and seriously injuring the rest, so that its value has been lessened one-half by the mere repetition of the leaf-fires. On many south mountain slopes many of the larger trees have been destroyed and only a brushy growth occupies their place. The practice of burning the woods for improving pasturage is a common one in parts of this county.

Many of the statements made about the practice of firing and the resultant damage to the woodland of Mitchell county will apply as well to parts of the adjoining counties of Yancey and Watauga.

MONTGOMERY COUNTY.—Besides the usual spring fires set for bettering pasturage a few destructive fires were reported to have occurred in the wake of the lumbermen in the eastern and southern parts of the county.

MOORE COUNTY.—The forests of this county have been devastated in the past few years by several large and destructive fires. One in 1892 consumed a large amount of timber in the southern part of the county and wiped the village of West End out of existence. Another in 1893 destroyed long-leaf pine timber to the value of $50,000. Fortunately, however, there were no destructive fires during the past year, although a large portion of the county was burned over for pasturage, or to protect property against an unexpected fire in a dry season.

NEW HANOVER COUNTY.—There were between 3,000 and 4,000 acres in this county, covered with young pine trees, burned over. Many of the young trees were killed; otherwise the damage was not great. Fires have greatly decreased in this county since the adoption of the stock law.

NORTHAMPTON COUNTY.—Only a few local fires were reported from this county.

ONSLOW COUNTY was visited by several destructive forest fires. One correspondent mentions five large fires which occurred on the west side of New river in the turpentine woods. These burned over 1,000 acres, with a loss of over $6,000, mostly of pine timber and young growth. Another person writing from the southern part of the county says that one fire in the neighborhood of Brown sound burned over about 8,000 acres, with a loss of $5,000. This fire originated from lightning. Another fire was mentioned near the Duplin county line which burned 300 acres. Burning is commonly practiced in this county for improving pasturage.

PERQUIMANS COUNTY.—Six fires occurred in April and May in Parkville and New Hope townships, burning over a large area. While the damage to standing timber was not large a great injury was inflicted on the underwood, which was all killed. These fires were purposely started, and are thought to improve the forests and drive out foxes and other wild animals. The practice of burning is here frequent.

RICHMOND COUNTY.—There were 6,000 to 7,000 acres of timbered land burned over in this county, the burned areas lying for the most part in the southern and eastern portions of the county. The most extensive one was in Marks Creek township. This burned over 1,000 acres of recently lumbered pine lands, killing all the young pines and a great deal of scrub oak timber. The wire-grass in the pine-barrens is fired every spring to better the grazing and to kill out the young growth.

ROBESON COUNTY seems to have suffered less than usual from fires during 1894. There were a great many small grass-fires which destroyed the undergrowth. In that portion of the county where the stock law is in operation there were very few fires.

SAMPSON COUNTY.—A correspondent from this county, which lies in the long-leaf pine region, estimated that there were 100,000 acres of timbered land burned over, with a loss of $50,000. The loss was mostly in young growth, to a less extent in timber. Burning is practiced for pasturage; but some fires are accidental. Most of the young pine growth in the forests, especially in the southern part of the county, is kept killed down. Another correspondent in the south-western part of the county states that there were no serious forest fires in his section during the past year, though there were many smaller ones.

WAKE COUNTY.—There is a considerable part of this county burned over every fall and spring, damaging a great deal of young growth. The same applies also to the adjoining counties of Nash and Chatham. Most of these fires are purposely started or escape from brush-fires where new ground is being cleared.

WAYNE COUNTY.—A large part of the southern section of this county, where it is very sandy and grassy, was burned over in the spring of 1894 for pasturage. Fires have killed all of the young long-leaf pines in this part of the county and only scrub oaks have taken their place.

REMAINING COUNTIES.—No reports, or none that were satisfactory, were obtained from Tyrrell, Washington, Dare, Hyde, Duplin, and Carteret counties, lying in the eastern section of the State. These counties, however, have a large proportion of their areas under swamp.

No reports were received from Wilkes, Stokes, Polk and Rutherford counties; but it is safe to say that a large part of the woodland in them was burned over, as was the case with the other piedmont counties of Burke and Caldwell.

No attempt was made to secure any specific information from the counties in the middle portion of the State, as these have hardwoods for a large part of their timbers. are thickly settled and the woodland is not so much injured by fires as elsewhere in the State, nor is the practice of burning so frequently resorted to in order to stimulate a scanty pasturage. There is still room, however, for a large reform.

AGGREGATE VALUE OF THE PROPERTY DESTROYED BY FOREST FIRES.

The difficulty of getting any reliable figures concerning forest fires is well shown in the incomplete reports from the several counties enumerated above. The nature of the subject explains the difficulty of obtaining full statistics. The large number of the fires—most of them being leaf-fires, which are of so frequent and general occurrence as to fix neither locality nor extent definitely in the memory of even those who saw them—and the inability of the most widely informed persons to estimate and report accurately beyond a local district, render the accumulation of exhaustive evidence upon the extent and destruction of these fires well-nigh impossible.

The damage as stated by the correspondents from the several reporting counties must have aggregated over $400,000, and there must have been between 800,000 and 1,200,000 acres burned over during the year. The damage attributed to Sampson county may be in excess of the actual losses sustained; but that from the other counties is in all cases probably underestimated, usually a third or a half smaller than in reality. Moreover, it is difficult to fix any standard by which losses can be ascertained; for only mature trees of certain merchantable species are considered in making the estimates, while the destruction of kinds with no commercial valuation as yet, and young growth, is counted as nothing. The counties reporting, too, embraced only about one-half of the area of the State, and the writer from his own observation of the damage wrought in previous years in these non-reporting counties would estimate the damage of them at over one-half of what it is in the other counties, or over $200,000. The entire loss in 1894 caused by forest fires in the State was certainly not less than $600,000; and from 1,500,000 to 2,000,000 acres of forest and waste lands were burned over. Only on a comparatively small part of this land, however, did the fires amount to more than leaf, or brush, or grass-fires; but, as has been shown already these result ultimately in the total destruction of the forest.

THE RELATIVE PREVALENCE OF FIRES IN DIFFERENT REGIONS.

The most numerous and severe fires in this State occur in the south-eastern counties in what is known as the long-leaf pine belt, or pine-barrens. High and thick grasses cover the ground and when dry in winter and spring form a fuel which carries fire before a wind at an alarmingly rapid rate. New Hanover county and parts of Robeson and Pender, where the stock laws are in force, have comparatively few forest fires. In the north-eastern counties there are neither so many fires nor is the damage resulting so great as it is farther south. Almost one-fourth of the definitely reported fires occurred in the south-eastern counties. So difficult is it to extinguish these wire-grass fires when once well under way that they have been known to burn from Hamlet to Fayetteville, a distance of forty miles.

Next in order, as far as number and extent of area burned, come the south-western mountain counties. The soil here is in many places in a condition in which it holds but little water, so the dry leaves burn well, and, wherever there are any Indians, the woods are regularly burned; but the Indians are by no means the only offenders. The mountainous parts of the piedmont counties suffer a great deal also, the ridges being steep, and much pine mixed with the hardwoods, so that a fire once started in a dry season burns briskly. The woods of the other counties west of the Blue Ridge are frequently burned when the season is dry enough; but the conditions in these are not as conducive to fires as in the south-western counties. The fires in the piedmont and mountain counties are leaf or brush-fires, rarely damaging directly anything except the bases of the trees.

The midland counties enjoy a comparative exemption, no very large fires being reported from this section. The people are beginning to realize their damage and prevent them and make every effort towards extinguishing them when once started. They rarely pass beyond brush or leaf-fires.

The fires in the eastern part of the State not infrequently pass from the grass to the pine trees which have been boxed and either ruin the face of the turpentine box or burn the boxes out so that the first storm will blow the trees down. After the face of a box has been burned only a low grade of rosin can be obtained from it, since the cinder darkens the resin.

THE ORIGINS OF FOREST FIRES.

By far the greater number of the fires, at least two-thirds of them, seem to be of intentional origin. And at least two-thirds of those purposely set are to secure or improve the pasturage. In the eastern part of the State these spring fires burn off the tough and thick old growth of wire-grass and broom-straw and the cattle can very early in the spring for several weeks get a fairly good pasturage. The grass, however, soon becomes too hard to be eaten. In the mountains fires are set to get rid of the leaves, so that the young grass can be easily reached in the spring; to burn off the stiff weeds, etc., and, what is much more important to the grazer, keep the young tree growth killed down. Keeping the young tree growth killed down exercises a twofold influence; it keeps the woods open so that grasses and herbage can grow, for these will not grow where it is too shady; and it keeps all pines and other conifers killed down, as these do not so readily sprout from the stump; while keeping them killed keeps the hardwoods, which cattle eat, of low growth, or always sprouting from the roots, so that they afford young and tender shoots within easy reach of cattle. It must be borne in mind, however, that these fires also destroy much of the grass and other annual and perennial herbs and shrubs, by destroying both the seeds and the plants themselves, in the forests and about the margins; and that in this way in the long run the pasturage in the forests is injured rather than improved by these repeated burnings.

Burning to protect houses, etc., is said to be a frequent cause for firing in the south-eastern counties. These are fires set on still days to get rid of the inflammable material, so that there will be no danger to farms and crops and houses from a chance fire in windy weather. A few fires were reported as set to enable hogs to find mast; and some by chestnut hunters; some from malice. In the turpentine orchards they are intentionally set to keep the growth down and get rid of the inflamable grass before the boxes are cut, or the sap begins to rise in the trees. Some were said to be set to get rid of insects, pine borers, etc., which is certainly using a very dangerous remedy for an insignificant evil.

Still other fires were reported as being started to drive game from cover. Most of the fires in the eastern and many in the western part of the State are started by indigent persons who are amenable to no law, who regard all property as open to destruction and forests as communal property; persons whose parents were hunters and who themselves are scarcely yet seriously affected by the civilization which defines property and allows to the individual its possession. The few fires that were reported as being of accidental origin were from hunters at night, campers, locomotives, lightning, and many from burning brush or logs in clearing land.

THE FOREST FIRE LAWS.

The general law in North Carolina relative to forest fires has remained on the statute books practically unchanged, and largely a dead letter, since it was enacted in 1777; and during this nearly a century and a quarter that has passed since that time, fire has destroyed more timber in the State than the lumberman has cut. The law is as follows:

"No person shall set fire to any woods, except it be his own property; nor in that case, without first giving notice in writing to all persons owning lands adjoining to the woodlands intended to be fired, at least two days before the time of firing such woods, and also taking effectual care to extinguish such fire before it shall reach any vacant or patented lands near to or adjoining the lands so fired."*

"Every person wilfully offending against the preceding section shall, for every such offense, forfeit and pay to any person who will sue for the same fifty dollars, and be liable to any one injured in an action, and shall moreover be guilty of a misdemeanor."*

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*Code, 1883, c. 7, s. 52.

Besides these laws relating to firing the woods there is the following one in regard to wagons and camps:

"If any wagoner or other person camping in the open air shall leave his camp without totally extinguishing his camp-fire he shall be liable to a penalty of ten dollars, to be recovered by any person suing for the same, and shall furthermore be liable for the full amount of damages that any individual may sustain by reason of any fire getting out from said camp, to be recovered by action in the Superior Court for the county in which said camp may be situated, or in which said damage may be done: *Provided*, that this section shall apply only to the counties of Cumberland, Harnett, Bladen, Moore, Hertford and Chowan"†.

The last section was passed in 1864–'65, is in operation only in six counties, and covers merely the case of accidental fires from campers. A statute similar in its provisions but imposing a heavier fine was passed in 1885. Its application extends only to thirteen counties, embracing most of those in the south-eastern part of the State. It is as follows:

"If any wagoner or other person camping in the open air shall leave his camp without totally extinguishing the camp-fire he shall be guilty of a misdemeanor, and on conviction fined not exceeding fifty dollars or imprisoned not exceeding thirty days, at the discretion of court, and also be liable to parties injured: *Provided*, that this statute apply only to the counties of Onslow, Pender, Edgecombe, Robeson, Wayne, Columbus, Cumberland, New Hanover, Bertie, Cabarrus, Harnett, McDowell and Davie."‡

There is besides the above a special law applying only to Pamlico county which was passed in 1889. This forbids any person from firing his woodland or marsh-land between May 1st and December 31st, unless it be separated by a swamp or stream from the lands of other persons.§

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*Code, 1883, c. 7, s. 53.
†Code, 1883, c. 7, s. 54.
‡Laws of North Carolina, 1885, c. 126, s. 1.
§Laws of North Carolina, 1889, c. 246, s. 1.

There is no doubt that section 52 of the Code of 1883, in regard to notice of intention to burn being sent to owners of adjoining woodland, is a dead letter. Over two-thirds of the woodland fires in this State are purposely set, and their annual number must reach at least 500 to 700. The writer is unable to learn of a single case in which such notice was given by the parties who started the fires. Although a large number of the fires annually occurring are traced to night hunters and a few to day hunters, there is no statute providing for fires originating either through carelessness or design of persons so engaged in hunting.

VARIOUS VIEWS UPON THE EXISTING FIRE LAWS.

A question was asked many persons concerning the efficiency of the existing forest-fire law; and for suggestions by which its efficiency could be improved or its provisions more effectually enforced. As all shades of belief and criticism found expression some of the more prominent and pertinent answers are given below.

Over one-half of the answers received indicated that their writers were ignorant of the existence of a law concerning forest fires or burning brush, etc. The chief idea expressed was that if a person's timber is seriously damaged by a fire started on his land by another person a suit can be brought for damages against the offender.

Such action is brought against railroad companies when fires are traceable to locomotives, and the assessed damage is usually paid in such cases.

A prominent correspondent in one of the piedmont counties said: "A law to prevent them (fires) would be difficult to enforce from the fact that it would be impossible to find out who does the firing."

One in eastern North Carolina wrote: "The no-fence law would prove the most efficacious in regard to those of intentional origin. Penalties should be enforced on the responsible parties when resulting from carelessness."

A writer in one of the south-western counties said: "I do not think the present law strong enough. Fires can only be prevented by passing strict laws with heavy penalties, and the strict enforcement of the same by the courts, which has not been done heretofore in this part of the State. Most of our people would be glad to see the law strictly enforced and a stop put to forest fires, as nothing is doing this part of the State more harm."

Another states: "We have plenty of law, but it is difficult to enforce it. The people need to be educated on the subject. Wherever the stock law has been introduced it has been found that the number of fires has been much reduced."

The writer of the following, like many others, appears ignorant of the existence of a fire law: "If a fire gets out on another's land not only should the party offending have to pay the damages but be subject to a suitable penalty for misdemeanor."

A person in one of the south-eastern counties whose lands, he says, have been much damaged by fires thinks it would be a good idea, in neighborhoods where fires are common, to have a man to look after them and see that offenders are reported and punished.

INFLUENCE OF LUMBERMEN IN CHECKING FIRES.

The influence that earnest millmen can exert, if so minded, will probably have more effect in their respective localities than the enactment of any law, no matter how severe and exacting may be its provisions. If these millmen, who form in reality one of the most interested classes, will take the matter in hand and make their employés understand that the protection of the young growth from fires is the assurance of labor for them, and it is the only way that the lumber industry can be perpetuated in this State, there will be gained a strong position of vantage. These laborers and the opinions held by them reach a class which writing of no sort can reach or influence; and it is this class which, either ignoring or neglecting to consider both the moral and pecuniary aspects of their acts, is responsible for far the greater number of the forest fires. If once the 15,000 men engaged in handling lumber and timber in this State are made to understand the advantage of protecting young forest growth and preventing fires, both by not setting them and by informing against those who do, public sentiment will come to their support, and we will begin to realize that the forests of the State may have a future as well as a present.

Although it is the lumbermen whom the fires—especially in the eastern part of the State—are most injuring and who would be the most benefited by their suppression, many of them express absolute indifference to any effort to mitigate the evil or to show the great loss occasioned by burning. They even appear to oppose any reform, and regard with decided disfavor any effort towards securing it. There are many millmen, however, who have aided in securing valuable *data*, and who express their readiness to co-operate in any measure which assures any abatement as to the number and extent of the fires.

RELATION OF THE BURNER TO THE FORESTS.

The turpentine workers also regard it as right to burn the grass and undergrowth in turpentine orchards, and in spite of the fact that the fire is liable to extend to the trees continue thus to fire the grass. It is impossible, however, to secure the boxed trees and the highly inflammable scrape-covered faces to the boxes as long as the undergrowth is burned; and it is equally as impossible to secure a regrowth of long-leaf pine as long as the burning grass consumes all seedlings and seed.

There are in the south-eastern counties clearly two classes who are interested in the burning: (1) the timber owner who sees his woodland yearly deteriorating in value at the hands of another, and who, it seems, can obtain no redress for his loss—cannot even secure a suppression of the agency of destruction; and (2) the person who for the immediate benefit he fancies is derived, from the act innocently or willfully, directly or through gross neglect, burns off the lands and destroys the timber or other property belonging to another citizen.

These two elements seem irreconcilable. As a matter of fact, however, their aims and dependencies are similar. It is apparent that the person who does the burning does not realize the relation between himself and the woodland. For in many cases, and as a general rule in the south-eastern counties of the State, a great part of his existence is dependent upon it, and that the more forest there is the greater will be his benefit, his cow or the ease with which he can work his rented turpentine boxes notwithstanding.

INFLUENCE OF THE NO-FENCE LAW IN CHECKING FIRES.

In a few places in eastern North Carolina the stock or no-fence law has been tried for a number of years; and, though the object in securing it was solely for the improvement of cattle and to lessen the cost of fencing, it has produced, in those localities where it has been tried, a decided change in the appearance of the young growth in the forest, and aided to lessen the number of fires by removing in a large measure the incentive to burning. To show the relative importance of protecting the forests to the pasturage gained by turning stock into the forest and firing the forest on the supposition that this improves the pasturage, it will suffice to state that the total value of all the cows in Moore county would not pay for the timber destroyed in that county alone during the years 1892 and 1893 by two fires. Harnett, Richmond and Bladen counties all show a similar state of affairs.

And not only would the forest fires become less frequent if the stock or no-fence law be generally introduced, but the provisions of the law quoted above in regard to the punishment of persons for firing should be rigidly enforced; and if, as the law now stands, it cannot be made operative it should be judiciously amended and provision made for its proper enforcement.

THE MAINE LAW IN REGARD TO FOREST FIRES.

The State of Maine presents conditions strikingly analogous to those in North Carolina. As is well known it is a great lumbering State. A people almost entirely dependent on agriculture and forest products for their prosperity, and whose manufacturing had never assumed importance, they finally recognized the interdependence of the agricultural and the forestal interests, and to secure the estoppage of fires and the unreasonable waste of timber, which goes on where it is abundant, adopted a series of laws relating to the suppression of fires. Their laws empowered a commissioner with the right to publish rules and to organize a corps of fire wardens and, finally, to bring suit against offenders to recover damages for loss sustained.

This law, being the first of its kind in the United States, is of sufficient importance to be summarized. The following excerpts and condensations are from the law as published in the first report of the Forest Commission of the State of Maine, 1891, which was obtained through the courtesy of Mr. Charles E. Oak, the present land agent of the State. While the provisions of this law are at present inapplicable to the conditions in North Carolina, they will serve to show what stress another State lays upon the strict enforcement of the laws relating to forest fires.

The law provided that the land agent—the State of Maine having large areas of forest lands for sale—should be forest commissioner. It is his duty to collect statistics about the forest resources and products of the State, and to receive the reports of the fire wardens. The selectmen of all towns are fire wardens, and so also are designated other persons living in various parts of the counties where fires occur. These latter are appointed by the county commissioners. It is the duty of the fire wardens to call out citizens in case of a fire to aid them in extinguishing the fire or controlling it; and to have the authority of deputy sheriffs to force persons to help to extinguish a fire. All persons not answering their summons are subject to a fine. The area burned and value of the property destroyed must be reported to the commissioner. It is the duty of municipal officers in towns, and of county commissioners with respect to other localities in their counties, to proceed immediately into a strict inquiry into the cause and origin of fires within woodland, and in all cases where the fires originate from unlawful acts to cause the offender to be prosecuted without delay. There are provisions concerning the clearing of rights of way by railroads, and the use of spark-arresters and other precautions; and provisions about hunters, campers, etc.

In a private letter the present commissioner states that the law is very satisfactory in its workings, and has greatly lessened both the number of fires and the losses caused by them. Its provisions, he says, are carried out and offenders brought to justice. It has, moreover, awakened a new spirit among the people—that of protecting young forest growth instead of destroying it.

LAWS IN OTHER STATES.

The Adirondack lands, belonging to the State of New York, are under a system of laws more strict in detail but similar in outline to those in force in Maine. The aim of the forestry commission legislation in New York is to restrict or supervise cutting of timber on State lands and to prevent fires occurring on the Adirondack mountains. The people of Pennsylvania, as well as those of Vermont, are taking an active interest in the protection of young growth and the prevention of its destruction by fires and cattle. Fires in Pennsylvania annually occasion a great loss of timber in the mountainous parts of that State, and that State now has a forest commission whose duty it is to disseminate information concerning the proper care and protection of forests, and to show the injurious effects of fires in woodland.

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ERRATUM.

Page 25, line 11 from top, read *Ailanthus* for *Ailianthus*.

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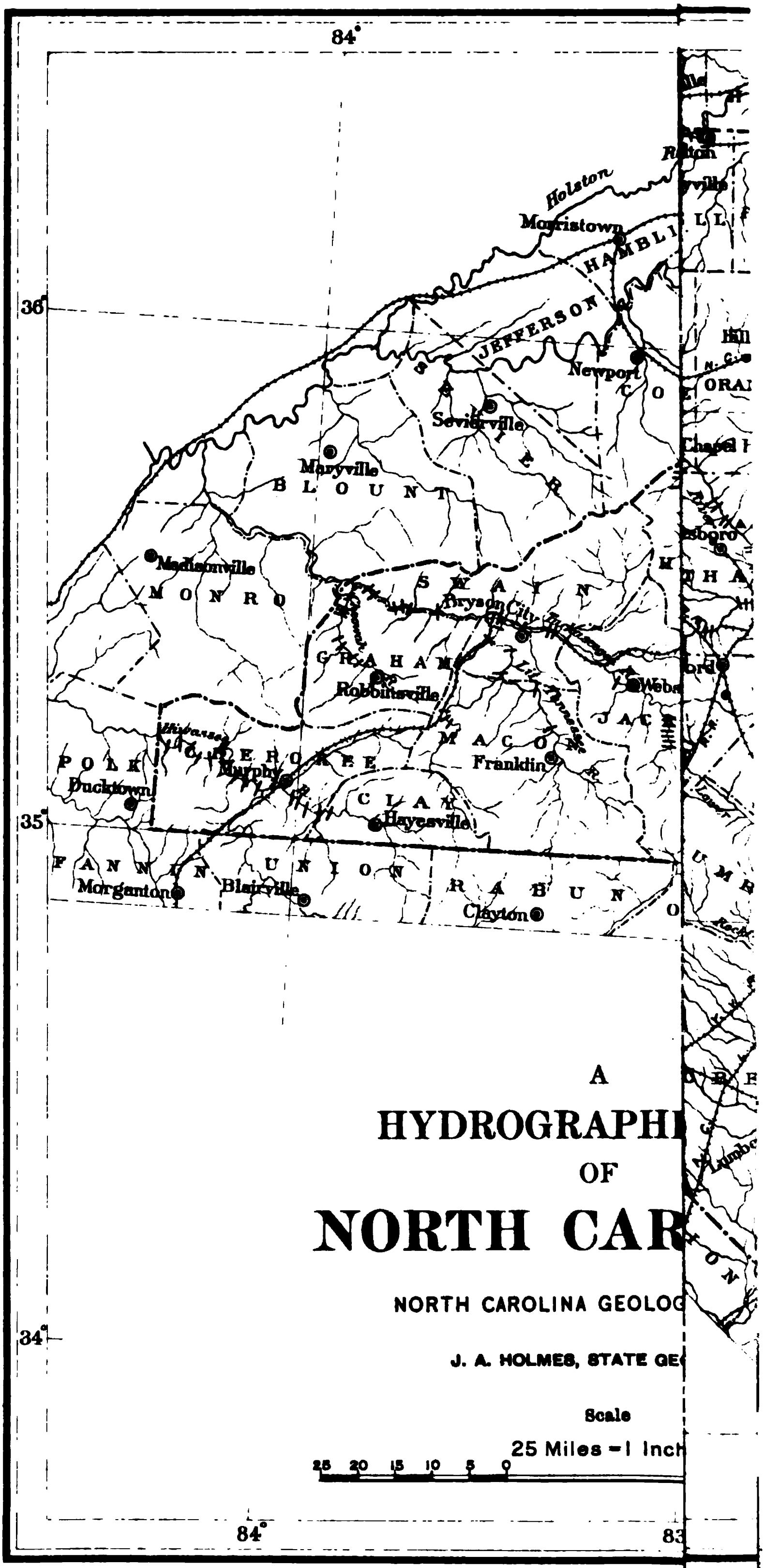

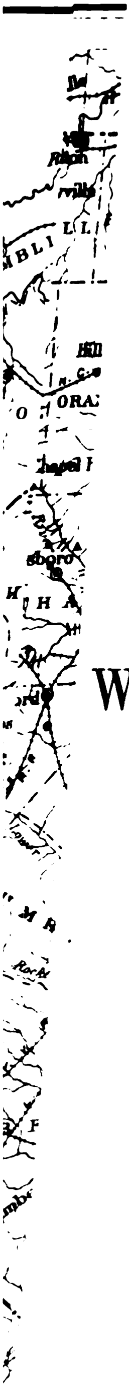

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LETTER OF TRANSMITTAL.

To His Excellency, Hon. D. L. Russell,
Governor of North Carolina, and Chairman of the Geological Board.

Sir:—The requests for information concerning waterpower in North Carolina received at the Survey office during the past few years have been so numerous and urgent that I believe it wise to publish in the form of a preliminary report such information as we have in hand relative to this subject.

The volume of water in the several larger streams in the state is being carefully measured from time to time; and level lines showing the amount of fall are being run along portions of these streams with a view of determining suitable places for power developments. This information will be embodied in later reports. I recommend the publication as Bulletin 8 of the Survey series the information already available.

Yours obediently,
J. A. Holmes.

Chapel Hill, N. C., September 1, 1898.

PREFACE.

The electric transmission of power developed during the past few years has awakened a new interest in waterpower throughout the entire country, and especially such powers as, owing to their location in regions inaccessible for railroad transportation, were not believed to be of importance. The publication of this *bulletin* as a preliminary report was decided upon with a view to meeting the urgent demands for information concerning these powers in North Carolina. In view of the fact that not enough of actual and long-continued measurements of the flow of the streams have been made to enable us to estimate accurately the value of the various powers, is was thought best for the purpose of a preliminary report to use as a basis for this, part of the 10th Census Report by Prof. Geo. F. Swain on the Waterpowers of the Southern Atlantic Watershed as relates to North Carolina.

This we have done, in general adopting the descriptions and power estimates found in his report and adding such additional data as were obtainable either by personal examination or by correspondence. The report in its final shape has been revised by Professor Swain; but he has not visited the region since 1881, and during these two decades changes in North Carolina, and throughout the South, have been great. He has been able to do little more than read the manuscript and suggest a few additions and corrections.

During the past three years gauging stations have been maintained by the United States Geological Survey and the State Survey coöperating, on each of the principal rivers in the state, at which have been made daily measurements of the height of the river surfaces; and occasional measurements of the flow and volume of water have been made by means of electric current meters. These measurements have, in general, confirmed Professor Swain's estimates as to the waterpower on the several larger streams. In the case of the Tar, Neuse and Cape Fear rivers, however, our measurements show his estimates for the absolute minimum (p. 54) are too high from 25 per cent. to more than 40 per cent.; but it has been thought best to allow his figures to remain as published in his 10th Census Report until the river measurements have been continued for a longer period of time.

The most uncertain points in a report of this character concern the estimates of the flow and power available on the streams, and it is hoped that all those who read this report will study with special care the remarks relating to this question on pages 49 to 67. Accurate data with respect to flow can only be obtained after a long series of observations. In Massachusetts, the Merrimac river has been utilized for power and its daily flow measured for over 50 years, and yet since the date of the original census report in 1881, the estimates of minimum flow have had to be materially altered. The readers of this report must, therefore, not exact great accuracy in the estimates given in the following pages. Indeed, the figures given must be simply considered as pointers indicating what may reasonable be expected in the way of waterpower during dry seasons.

PART I

WATERPOWER IN NORTH CAROLINA AS INFLUENCED BY PHYSIOGRAPHIC CONDITIONS

J. A. HOLMES
C. F. VON HERRMANN
GEO. F. SWAIN

PAPERS ON WATERPOWER IN NORTH CAROLINA.

CHAPTER I.

GENERAL PHYSIOGRAPHIC FEATURES OF NORTH CAROLINA.[1]

PHYSIOGRAPHIC PROVINCES.

The southeastern United States may be divided naturally into three well-defined provinces: the coastal plain region, which skirts the Atlantic and the Gulf from Cape Cod to the Rio Grande, extending inland from 100 to 200 miles, and extending seaward beyond the present coast line as a submerged plain for a distance nearly as great; the Appalachian mountain region, extending from northern Alabama to New Jersey and the Piedmont plateau region, which lies between these two from the Hudson river to central Alabama.

Only a small portion of the mountain region belongs with the south Atlantic watershed, but the entire region demands consideration in a study of its rivers and waterpowers. In the Carolinas the Blue Ridge mountains, which constitute the eastern front of this Appalachian region towards its southern end, form the divide separating the waters that flow into the Atlantic from those which find their way through the Ohio and Tennessee into the Mississippi, while northward the Alleghanies often constitute the divide, so that in Virginia and northward the larger rivers rise to the westward of the Blue Ridge, and flow eastward across it in deep gorges, while in North Carolina and southward the more important streams are those which rise either along the crest and southeastern slopes of the Blue Ridge or among the hills of the Piedmont plateau, and flowing across this latter and the coastal plain region, find their way into the Atlantic. The outlines of the physiographic regions and the general drainage systems in North Carolina are indicated on the accompanying map (fig. 1) to be found on the next page.

THE COASTAL PLAIN REGION.

The coastal plain region has been built up of unconsolidated sands, gravels, loams, clays and marls of recent geologic age, which inland

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[1] By J. A. Holmes.

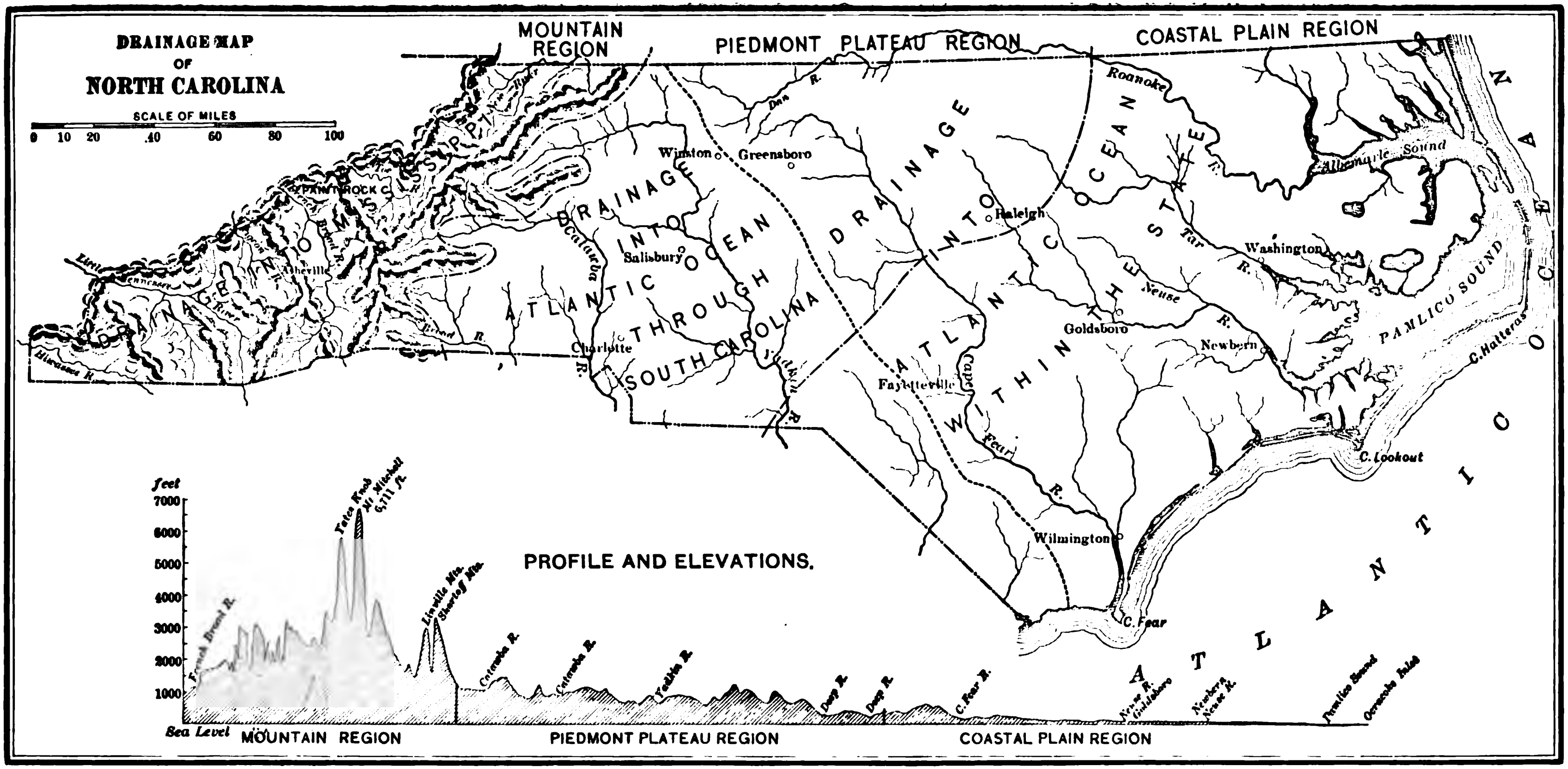

FIG. 1.—MAP OF NORTH CAROLINA SHOWING PHYSIOGRAPHIC REGIONS AND DRAINAGE; WITH A PROFILE SECTION FROM THE FRENCH BROAD RIVER AT PAINT ROCK TO OCRACOKE INLET [BETWEEN CAPES HATTERAS AND LOOKOUT].

Had the profile section been drawn either North or South of the French Broad, it would have shown higher mountains at its western end.

rest against the red lands and on the eastern sloping rocky surface of the hill country—the eastern margin of the Piedmont plateau. This contact between the two regions is one of the most clearly defined of natural boundaries, and is known geographically and industrially as the "fall line," along which are located, at the head of navigation on the more important streams, a number of important cities and towns, such as Washington, Richmond, Petersburg, Weldon, Columbia, Augusta and others given in the table below. The canals and other works constructed long ago for improving navigation at some of these places are now being used to develop waterpowers, and the cities are fast becoming manufacturing centers.

In New Jersey, Maryland and Virginia many of the streams of the Piedmont plateau cross its eastern margin at the fall line in deep, rocky gorges, and the rushing river torrents merge immediately below into tidal estuaries. Further south, however, the elevation of the fall line increases until on the Ocmulgee river at Macon, Ga., it is 250 feet above the sea. The following table shows the relative elevation of this boundary line at different points where it is crossed by the larger rivers:

RIVERS.	PLACES.	ELEVATION ABOVE MEAN TIDE. Feet.
James	Richmond, Va.	0.0[1]
Appomattox	Petersburg. Va.	0.0[1]
Roanoke	Weldon, N. C.	26.0
Tar	Rocky Mount, N. C	59.5
Neuse	Smithfield, N. C	100.0
Cape Fear	Averasboro, N. C.[2]	85.0
Pee Dee	C. C. R. R. crossing	106.0
Wateree	Ten miles above Camden, S. C.	125.0
Congaree	Columbia, S. C	129.0
Savannah	Augusta, Ga	125.0
Ogeechee.	Shoals of Ogeechee, 8½ miles below Mayfield, Ga.	210.0
Oconee	Milledgeville, Ga.	220.0
Ocmulgee	Macon, Ga.	250.0

On the seaward side of this fall line, or fall-line zone as it might be more properly designated, we have the sluggish, navigable rivers which make their way southeasterly across the coastal plain region in valleys which, near the fall line, are usually narrow, from 50 to 100 feet deep, and with rather steeply-sloping sides, which at intervals form vertical bluffs on alternate sides of the streams. Usually the southwest side is the steeper, and the bluffs are more generally on this side. Further seaward the valleys become wider and less deep.

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[1] This table is only an approximation. It was not possible to get accurate elevations on account of the difference in the datum-planes used by the various railroad companies. For instance, Richmond and Petersburg are at the head of tide water; yet the rivers there are probably several feet above mean tide at Norfolk. In some cases the above figures have been obtained by estimating the amount of fall above points whose elevations were given.

[2] Just below Smileys falls.

The river courses in this eastern region are often exceedingly tortuous. The banks are composed of sands and clays which, along the upper reaches of the streams, are often found to be of cretaceous or Potomac age, while further seaward these older deposits are buried beneath the tertiary sands and marls, and usually all of these are overlaid by the still more recent sands and loams of the Lafayette and Columbia formations. This unstable character of the banks is unfavorable to navigation, inasmuch as the rivers frequently undermine trees, depositing both the tree and materials of the bank in the channels, and even cut new channels for themselves where conditions are favorable.

The country between the streams near the fall line has a surface that is quite undulating, rising in the sand-hill regions between the Cape Fear and the Savannah to an elevation of 500 feet, while further seaward the surface becomes more nearly level, with an elevation of from 10 to 50 feet above mean tide. Along the seaward margin the land surface is intersected by and interspersed with bays, estuaries and sounds, and even the land surface contains numerous and large swamp areas, such as the great Dismal Swamp in Virginia, and occasional small lakes, often partially or wholly surrounded by such swamps. The general seaward slope of the land surface from the fall line ranges from one to three feet to the mile. The forests, which still cover more than 60 per cent. of the total area of the region, are composed mainly of pines on the uplands and deciduous trees in the swamp areas.

Considering the coastal plain region as a whole, its surface features may be described as those of a region but recently and but slightly elevated above the sea, and a large part of whose surface is so nearly level and so unaffected by erosion that it is poorly drained. This condition, which results in the existence of numerous and large swamp areas, and the porous nature of the soil in the more sandy portions which enables it to act as a sponge in absorbing and holding rain water, gives remarkable uniformity to the flow of the streams which have their sources in this region. Along its western border, however, where we find the typical sand-hill country, the hills and ridges are more numerous and irregular, rising to elevations of from 300 to 500 feet, while the valleys and ravines are carved more deeply, and in places have made their way back into the heart of the region. In explanation of the topographic features of this sand-hill country it may be suggested that the region is not only more elevated, but has been either much longer above the sea than the country to the east, or if recently submerged, the period of submergence was so brief that the pre-existing topographic features were not obliterated thereby. It is in this sand-hill country that we find such industrially important though small streams as Rockfish and Hitchcocks creeks (see pages 138 and 190).

In North Carolina the coastal plain region extends inland from the coast 120 to 160 miles, and has an area of approximately 25,000 square miles of which more than half is still covered with pine forests. The upland soils are loamy sands, loams, and sandy and common loams, rarely stiff, moderately fine and even-grained. To the north of the Neuse river loams and sandy loams are the more frequent upland soils; to the south of this river they are more generally sandy. In the more eastern portion of this region, adjacent to the sounds and to the Atlantic, are numerous and extensive swamps which have their origin in the insufficient surface drainage of recent uplifted areas, that are often underlaid by impermeable strata, or in the gradual cutting off and filling up by silt and vegetable matter, of small bodies of water. Their soils vary considerably even in different portions of each swamp, being in their interior generally peaty and about the margins either sands and sandy loams, or clay loams and silt. Where these swamps border the larger streams that have their headwaters in the Piedmont region, their soils are generally an admixture of silt and vegetable matter and quite fertile.

THE PIEDMONT PLATEAU REGION.

The Piedmont plateau region, lying between the coastal plain and the mountains, and extending from Alabama to New Jersey, exhibits a diversity of characteristics, though there are many features common to the entire region. Along portions of its eastern margin, near the fall line, its hills are no higher and its valleys no deeper than those of the adjacent coastal plain region. Especially is this true where, as in the southern half of North Carolina, the Piedmont plateau region includes on the east a narrow belt of red sandstone which in places has been removed even more rapidly by the atmospheric agencies than have the sand-hills on the east side of the fall line. But generally the hard crystalline rocks and reddish soil of the Piedmont plateau are to be found at the fall line, and exhibit there the undulating surface characteristics of the typical red-hill country, the elevation of the surface near the coastal margin ranging from 300 to 600 feet. The eastern half of the region, taken as a whole, has an average elevation of nearly 750 feet, while the western half averages nearly 1200 feet.

Towards the western margin of this region the hills rise higher and higher above the general plain until in many cases they may be fairly considered as mountains, South and Brushy mountains in North Carolina having elevations between 2000 and 3000 feet. Toward the eastern margin the hills rise but little above the general plain, but the river channels are deep. It will be readily understood that as compared with the young and undeveloped topography of the coastal plain region, that of the Piedmont plateau is much older, more varied, and its history more complex. More than once in its recent history its surface has been so extensively removed by weathering and eroding agencies that it has been reduced, at least approximately, to a base-level plain, at no great elevation above the sea, and with only a few scattering hills and ridges rising above this plain, remnants which, owing to the obduracy of their component materials, have withstood the destructive agencies of the atmosphere even to the present time. Meanwhile, however, the surface has been lifted to higher levels above the sea, the streams have quickened their pace, carrying on anew the work of erosion until now we have left of this recent base-level plain only a secondary series of low hills and broad irregular ridges to indicate its position.

The soils, which in the main have been formed from the decay of rocks in place, are generally loams which are more gravelly and sandy and deeper in the granitic areas, and more clayey and shallow in the slaty belts. The forests, which are composed mainly of deciduous hard woods, here and there interspersed with short-leaf pines, occupy from 50 to 70 per cent. of the total area of the region.

In North Carolina this Piedmont plateau region approximates 125 miles in width and 900 feet in average elevation. Its highest ridges (South mountains) reach a height of 3000 feet above tide; but along its extreme east border its elevation does not average more than 400 to 500 feet. Its area approximates 21,000 square miles, of which more than one-half is covered with forests. The average southeasterly slope of the surface of this region is approximately three and one-half feet to the mile; but the possibility of developing waterpower on the several streams depends less upon this average slope than upon the concentration of portions of the fall at certain places, where for distances of a few rods, or at most a few miles, the streams assume the character of rapids, shoals or cascades. The descent of the surface of the various important streams of the region will be given in the body of this report as each stream is described. As may be seen from the sketch map on page 78, the several geological formations that go to make up the Piedmont plateau region cross the state obliquely, parallel to the mountains and to the seashore. In the main they form a succession of belts of slates and schists, granites and gneisses, across the steeply upturned and eroded edges of which the streams have carved their channels in making their way seaward. The fact that these rocks differ in character and are eroded with varying rapidity by the water currents, gives rise to the conditions that produce rapids, cascades and falls, and in this way makes practicable the development of waterpowers, as is described more fully on pages 68 to 76.

THE APPALACHIAN MOUNTAIN REGION.

The Appalachian mountain region, which extends from Alabama to New York, may be said to culminate in North Carolina, since it reaches here its maximum development. Along portions of its western slopes the boundary line of the region is obscure, the highly folded and uplifted strata of the mountains becoming only less corrugated in the hills and ridges of the adjacent plateau on the west; but other portions of this western, like the eastern, boundary are so well marked as to constitute not a gradual transition but an abrupt change from plateau to mountain conditions. The rugged mountain range on the eastern border is broken only by such occasional water gaps as those through which flow the Susquehanna, the Potomac, the James, and a few smaller southern streams.

In North Carolina this region embraces an irregular mountainous tableland, lying between the steep and well-defined escarpment of the Blue Ridge on the southeast, and the less regular, but in places equally prominent northwestern slope of the Great Smoky mountains. Numerous cross ridges, separated by narrow valleys and river gorges, connect these two mountain ranges. The region, taken as a whole, has a general average elevation of about 2700 feet above sea-level; but there are many mountain peaks that rise about 5000 feet, and a considerable number that are over 6000 feet high. Mt. Mitchell, the highest of the Black mountains, has an elevation of 6711 feet. The total area of the region approximates 6000 square miles. The mountain slopes, though usually steep, are forest-covered and have a deep fertile soil, usually a loam of varying physical character, but generally rich in humus, porous and easily cultivated. The Blue Ridge is in this state the great divide between the Atlantic and the Gulf waters. The streams which have their sources on the northwest slope of these mountains for the most part flow in a northwesterly direction into the tributaries of the Tennessee, having cut their way across the upturned edges of the folded strata that make the Great Smokies and their northeast extension, the Iron and Stone mountains; while further north the waters of the region flow in a northerly direction between the mountain ranges, and make their way into the Ohio. The character of the streams of this region and their basins are discussed more in detail in Part III of this report (page 233), and the geological conditions favorable to the development of waterpowers are described briefly in the following pages (68 to 76).

CHAPTER II.

CLIMATIC CONDITIONS AFFECTING WATERPOWER.[1]

GENERAL CLIMATIC CONDITIONS.

In considering the climate of any district with reference to its important influence on waterpower, the various elements which modify or control the amount of precipitation should receive the largest share of attention. Pressure, temperature, movements of the wind, and the like, may be discussed briefly for the purpose of a satisfactory general view of the subject, but these elements have a somewhat variable and complicated influence on rainfall, which is less clearly understood than the permanent effects of geographical position or topographical features. The climate of North Carolina is determined by its location in the warm temperate zone, but is modified by three important factors: the proximity of the ocean on the east, the distance of the state from the prevailing course of cyclonic storms, and lastly, the gradual elevation of the land towards the west, until in the summit of Mt. Mitchell the highest altitude east of the Rocky mountains is attained.

The statistical material employed in the tables has been obtained from the publications of the United States Weather Bureau and of the North Carolina Section (formerly the State Weather Service), and includes data collected to the end of the year 1897. For convenience of treatment the state has been divided into three districts, which correspond roughly with the geological subdivisions—the coastal plain, the Piedmont plateau and the mountain regions. The eastern district (corresponding to the first of these in a general way) includes meteorological stations having elevations of less than 100 feet, the central district elevations between 100 and 1000 feet, and the western district all points over 1000 feet above sea-level. Each division has in some respects climatic features peculiarly its own.

In the *eastern district*, which includes that portion of the state bordering on the Atlantic, the influence of the proximity of the ocean, the indentation of the land by large bays and sounds, and the projection of the coast line beyond the normal trend, is immediately evident in the increased rainfall on the coast, especially between Hatteras and Cape Lookout, as well as in the lessened changes of temperature, both diurnal and seasonal. It has been the fashion to ascribe the almost insular or marine climate of this section to the influence of the Gulf Stream, but the facts that a considerable body of cooler water lies between the Gulf Stream and the coast, and that east and southeast winds are the rarest of all winds in North Carolina, and are inadequate to explain the warmer, moist climate of this region, appear to indicate that the Gulf Stream exerts less influence in this direction than was formerly supposed. The annual mean temperature varies in the east from 64° Fahr. at Southport to 59° Fahr. at Weldon, and permits in the southern portion of the district the growth of vegetation of semi-tropical origin, and the cultivation of rice, early fruits and vegetables.

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[1] By C. F. Von Herrmann, Section Director, U. S. Weather Bureau.

In the *central district* the extremes of temperature become greater, the rainfall is less; the southern portion shows a high degree of summer heat, due in part to the sandy nature of the soil. Central North Carolina is, however, by no means as warm as central South Carolina, and the northern portion of this district is not greatly different from central Virginia. The annual mean temperature varies from 62° Fahr. at Rockingham to 57° Fahr. at Saxon. It is often the case that this section receives more snow in winter than other portions of the state.

In the *western district* the influence of elevation is supreme. The summers are cooler, the winters more severe, the air drier and more salubrious. The trend of the mountains from southwest to northeast influences the prevailing winds. The great diversity in topographical features gives rise to many interesting climatic peculiarities. The rainfall is large, especially so at the south end of the Appalachian system, while, on the other hand, many central valleys possess as small a rainfall and as mild a climate as many points east of the Blue Ridge. It is well to remember that several meteorological stations in the west have elevations of nearly 4000 feet. The annual mean temperature varies from nearly 60° Fahr. at Salisbury and Charlotte east of the mountains, to 49° Fahr. at Linville, which is nearly the mean annual temperature of Boston or Chicago.

The position of North Carolina with reference to the general path of low barometric areas is a fortunate one. Probably not more than 20 per cent. of the storms observed in the United States cross the state. The great highway for these storms is the Lake Region, and a very large majority of them pass off the United States coast over New England. While not causing heavier rainfall in the north, they do make the weather extremely severe and changeable, and give that section a high percentage of cloudiness and a high relative humidity; while in North Carolina longer periods of settled weather are experienced, fogs, though frequent enough, rarely last during the day, and cheerful, sunny weather is the rule.

The state lies in the course of sub-tropical storms from Florida which are often violent, and are accompanied by heavy precipitation, but usually pass over the state with great rapidity. They occur chiefly from August to October.

The prevailing winds are from the southwest, or in fall and winter, frequently from the northeast; the movement is generally light and variable in the interior, but often dangerous on the coast during the passage of sub-tropical storms, giving to Hatteras its world-wide reputation. In winter the winds from the south, east and northeast are wet winds; the shift to southwest is usually followed by rapidly clearing weather; in summer, wind directions and movements are very irregular. In general, the resultant annual movement is from the west.

The average *cloudiness* of the state is between 40 and 50 per cent., with a somewhat larger average on the eastern slope of the Blue Ridge.

The annual relative humidity is about 80 per cent. on the coast from Hatteras to Wilmington, is 75 per cent. in the central-east portion of the state, and in the west generally about 70 per cent. As evaporation increases with higher temperature, the maximum humidity occurs in July or August.

TEMPERATURE.

It is evident from its physical features alone that a wide variation must exist in the mean temperature of the different sections of North Carolina. In Table I (p. 30) is presented the annual and seasonal mean temperature at a large number of stations in the state, of which 28 have records covering a period of 10 years or more. From all data the normal annual mean for the state has been found to be 59° Fahr. The seasonal temperatures for the different districts are as follows:

	Spring.	Summer.	Autumn.	Winter.
Eastern District	59°	77°	62°	45°
Central District	59°	77°	60°	42°
Western District	56°	73°	57°	40°
For the state	58°	76°	60°	42°

The annual mean for the state has varied during the past 26 years between 61° Fahr. in 1890 and 57° Fahr. in 1895. From the data given it is seen that autumn is warmer than spring in nearly all parts of the state. January is the coldest month of the year, with no normal, however, lower than 31° Fahr., while July is the warmest, with no normal higher than 81° Fahr. During exceptionally warm summers July means as high as 84° Fahr. have occurred (Wilmington, Newbern, Weldon). The lowest January mean on record is 24° Fahr. at Highlands in 1893.

During the past ten years the state has probably experienced as wide a range in actual temperatures as is likely to be again observed. Remarkably warm weather occurred during the summers of 1887 and 1896, with extremes as high as 107° Fahr., while the often-quoted cold winters of 1834 and 1856 must now certainly yield their places in climatic history to those of 1893 and 1895.

Ordinarily the rivers of North Carolina remain open throughout the year, but during such winters as occurred in 1857, 1886, 1893 and 1895 all the rivers, and even the northern sounds, were frozen over. In 1893, for instance, the Cape Fear river at Fayetteville, the Neuse at Newbern, the Roanoke at Weldon, and Albemarle sound from Elizabeth City to Roanoke Island were covered with ice.

The extremes presented in Table II (p. 33) will be of interest in this connection.

If the distribution of temperature be studied graphically it is found that the isotherms do not follow the lines of latitude, but cross them in a southwest-northeast direction almost parallel with the Blue Ridge; but in summer there is a decided northward trend of the isotherms from the coast to the central portion of the state before they curve around the southern end of the Appalachian system.

TABLE I.—TABLE OF AVERAGE MONTHLY AND SEASONAL MEAN TEMPERATURES AT STATIONS IN NORTH CAROLINA.

RECORDS FROM 1820 TO 1897 INCLUSIVE.

EASTERN DISTRICT.	Latitude, ° ′	Longitude, ° ′	Elevation, ft.	Length of record, years.	AVERAGE MONTHLY AND ANNUAL MEAN TEMPERATURES.													SEASONAL TEMPERATURES.			
					Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Spring.	Summer.	Autumn.	Winter.
Beaufort*	34°43′	76°41′	18	5	46.5	47.7	53.1	59.4	69.4	75.3	79.8	80.9	74.7	64.2	56.9	48.0	63.0	60.6	78.7	65.3	47.4
Coinjock	36°20′	75°52′	20	6	41.4	42.1	47.9	55.5	64.6	72.4	78.4	76.0	70.9	61.0	50.5	42.3	58.6	56.0	75.6	60.8	41.9
Cape Lookout	34°36′	76°36′	15	6	47.6	47.0	52.8	59.9	67.7	75.0	80.2	79.4	74.7	66.1	55.6	47.2	62.8	60.1	78.2	65.5	47.3
Edenton*	36° 3′	76°36′	30	5	41.5	43.4	49.6	58.7	68.4	74.2	79.9	79.8	71.6	60.3	52.3	40.8	60.0	58.9	77.8	61.4	41.9
Fort Macon	34°42′	76°40′	20	14	44.9	46.5	51.0	59.1	68.6	76.0	80.0	79.1	75.1	65.3	56.2	47.9	62.5	59.6	78.4	65.5	46.4
Goldsboro*	35°23′	78° 0′	102	21	42.6	47.3	52.0	60.6	69.6	77.2	79.8	78.3	72.8	61.6	51.9	44.4	61.5	61.7	78.4	62.1	44.8
Hatteras*	35°15	75°40	11	23	45.3	47.0	50.0	57.2	66.6	74.1	77.9	77.5	73.7	64.4	55.9	48.2	61.5	57.9	76.5	64.7	46.8
Kitty Hawk*	36° 0′	75°42′	9	23	42.5	44.5	47.8	55.4	64.9	73.5	78.0	77.4	72.8	63.4	58.5	45.9	60.0	56.0	76.3	63.2	44.3
Littleton*	36°26′	77°54′	380	7	36.4	39.9	46.9	57.5	65.4	75.0	77.2	76.4	70.9	57.1	48.3	41.6	57.7	56.6	76.2	58.8	39.3
Lumberton*	34°38′	78°59′	...	10	45.1	41.7	53.1	62.9	70.6	77.4	80.0	78.3	72.0	61.6	52.9	46.7	61.9	62.2	78.6	62.2	44.5
Murfreesboro	36°26′	77° 5′	75	5	40.7	44.9	49.1	56.9	66.5	75.4	77.3	76.4	68.6	58.1	49.1	42.6	58.8	57.5	76.4	58.6	42.7
New River Inlet	34°32′	77°18	...	5	42.2	48.4	49.3	58.8	69.6	74.7	79.1	77.6	73.1	65.2	54.4	47.8	61.7	59.2	77.1	64.2	46.1
Newbern*	35° 6′	77° 2′	12	21	42.6	47.0	51.6	59.6	68.4	75.9	78.9	77.3	72.9	61.9	53.4	46.1	61.3	59.9	77.4	62.7	45.2
Norfolk, Va*	36°51′	76°17	69	27	40.5	42.8	47.0	56.5	66.6	74.9	78.6	76.9	71.2	60.6	50.6	42.9	59.1	56.7	76.8	60.8	42.1
Portsmouth	35° 2′	76° 4′	5	5	43.8	46.5	50.8	58.1	67.6	74.1	79.6	78.3	74.8	67.6	55.8	45.8	61.9	58.8	77.3	66.1	45.4
Southport*	33°55′	78° 1′	34	42	47.0	49.7	54.4	62.3	71.2	77.7	80.6	79.5	75.1	65.6	56.8	49.7	64.1	62.6	79.3	65.8	48.8
Scotland Neck	36° 7	77°32′	50	10	40.7	43.5	48.9	55.8	65.7	74.0	77.8	75.6	70.1	59.3	49.4	41.0	58.5	56.8	75.8	59.6	41.7
Sloan*	34°45′	77°32′	50	5	44.8	44.5	53.4	61.2	70.0	76.0	77.1	78.1	73.8	61.2	54.0	46.5	61.7	61.5	77.1	63.0	45.3
Tarboro*	35°50′	77°35′	50	12	41.1	44.5	48.9	59.5	69.1	76.0	78.7	77.4	71.5	59.2	51.0	43.1	60.0	59.2	77.4	60.6	42.9
Weldon*	36°24′	77°32′	81	26	39.3	42.8	47.8	57.7	68.2	75.9	79.3	76.8	71.0	58.9	48.5	41.1	58.9	57.9	77.3	59.5	41.1
Willeyton*	36°28′	76°32′	45	8	38.2	44.3	48.6	58.7	66.8	74.5	76.6	76.0	71.0	58.4	50.2	42.4	58.8	58.0	75.7	59.9	41.6
Washwoods	36°33′	75°53′	10	6	40.9	44.2	44.5	54.3	66.3	74.8	79.3	77.3	72.4	61.3	51.8	43.5	59.2	55.0	77.1	61.8	42.9
Wilmington*	34°14′	77°57′	52	27	46.7	50.0	53.5	61.6	69.5	76.7	79.6	78.2	73.5	63.5	54.7	48.2	63.0	61.5	78.2	63.9	48.3

* Indicates that records were continued through 1897. Temperatures in Fahrenheit degrees.

TABLE I.—*Continued.*

CENTRAL DISTRICT.	Latitude, ° ′	Longitude, ° ′	Elevation, ft.	Length of record, years.	AVERAGE MONTHLY AND ANNUAL MEAN TEMPERATURES.													SEASONAL TEMPERATURES.			
					Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Spring.	Summer.	Autumn.	Winter.
Attaway Hill	35° 25′	80° 12′	850	11	38.2	40.7	46.8	56.8	63.8	73.5	77.4	75.6	68.2	55.5	45.0	38.1	56.6	55.8	75.4	56.2	39.0
Chapel Hill*	35° 54′	79° 4′	500	41	39.8	44.3	49.0	59.2	67.8	75.9	78.4	76.5	71.3	59.6	49.9	42.6	59.5	58.7	76.9	60.8	42.2
Fayetteville*	35° 6′	78° 53′	170	13	42.1	45.2	53.2	61.1	70.3	76.2	79.3	77.1	70.8	61.6	50.7	42.6	60.9	61.5	77.5	61.0	43.8
Greensboro*	36° 4′	79° 49′	843	15	40.4	43.7	50.6	59.0	68.4	75.8	78.3	76.6	71.0	61.0	48.3	41.9	59.6	59.3	76.9	60.1	42.0
Henderson*	36° 20′	78° 23′	490	5	39.4	40.1	50.9	57.6	68.4	75.4	78.4	77.4	73.0	58.3	50.0	41.8	59.2	59.0	77.1	60.4	40.4
Louisburg*..........	36° 7′	78° 18′	375	7	36.6	40.8	48.9	58.7	67.6	75.4	76.8	76.5	71.1	57.8	47.9	40.3	58.2	58.4	76.2	58.8	39.2
Moncure*	35° 39′	79° 0′	300	5	40.4	41.0	51.6	60.0	68.2	75.1	78.1	76.5	72.2	58.2	51.0	41.1	59.5	59.9	76.6	60.5	40.8
Monroe*	34° 59′	80° 34′	586	5	41.5	45.0	50.5	62.0	69.2	75.4	78.2	76.2	70.4	58.9	52.9	46.2	60.5	60.6	76.6	60.7	44.2
Oxford	36° 22′	78° 25′	475	7	37.8	41.9	46.4	58.3	66.1	74.6	79.2	75.6	68.2	56.1	45.4	37.8	57.3	56.9	76.5	56.6	39.1
Oak Ridge*..........	36° 10′	80° 0′	885	8	37.5	41.6	47.0	57.8	66.1	74.2	75.9	75.0	69.2	56.1	48.0	40.5	57.8	57.0	75.0	57.8	39.9
Pittsboro*	35° 42′	79° 12′	480	9	38.2	42.2	46.9	57.6	65.6	73.5	75.6	74.6	69.8	56.2	48.0	41.6	57.5	56.7	74.6	58.0	40.7
Raleigh*..........	35° 45′	78° 37′	375	27	41.0	44.1	49.4	59.1	68.2	75.7	78.0	76.4	71.1	58.7	50.4	43.7	59.6	58.9	76.7	60.1	42.9
Roxboro*	36° 26′	78° 58′	600	5	35.9	39.5	48.7	58.7	66.7	74.5	77.1	76.1	71.1	57.1	48.9	40.6	57.9	58.0	75.9	59.0	38.7
Rockingham*	34° 58′	79° 46′	210	5	41.8	46.0	54.6	64.2	70.9	77.4	80.8	78.7	74.3	61.5	51.9	44.5	62.2	63.2	78.8	62.6	44.1
Southern Pines*.......	35° 13′	79° 22′	400	7	41.5	45.5	52.0	61.8	69.1	77.3	78.1	77.2	73.4	61.3	51.7	47.2	61.3	61.0	77.5	62.1	44.7
Soapstone Mount*.....	35° 46	79° 37′	900	9	37.8	39.5	47.2	57.0	65.6	73.7	76.1	74.0	69.1	55.5	46.8	41.1	57.0	56.6	74.6	57.1	39.5
Selma*..........	35° 31′	78° 21′	225	8	39.3	44.3	50.5	60.5	68.1	76.6	78.2	77.0	72.0	59.4	50.6	43.1	60.0	59.7	77.3	60.7	42.2
Saxon*..........	36° 22′	80° 6′	900	7	34.9	39.9	48.1	57.8	66.1	74.0	77.1	76.2	69.4	54.8	46.2	39.5	57.1	57.3	76.0	56.8	38.1

* Indicates that records were continued through 1897. Temperatures in Fahrenheit degrees.

TABLE I.—*Continued.*

WESTERN DISTRICT.	Latitude, ° ′	Longitude, ° ′	Elevation, ft.	Length of record, years.	AVERAGE MONTHLY AND ANNUAL MEAN TEMPERATURES.													SEASONAL TEMPERATURES.			
					Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Spring.	Summer.	Autumn.	Winter.
Asheville*	35° 37′	82° 30′	2250	23	37.8	39.8	45.7	54.8	62.6	69.6	72.0	70.7	64.9	53.2	45.2	38.9	54.5	54.4	70.8	54.4	38.8
Charlotte*	35° 13′	80° 51′	808	22	40.6	44.6	49.6	60.0	68.6	75.7	78.4	76.5	71.2	60.0	49.8	43.3	59.9	59.4	76.9	60.3	42.8
Flat Rock*	35° 15′	82° 25′	2214	5	35.3	40.0	48.5	54.0	62.5	69.3	71.9	70.4	65.5	53.0	45.5	39.4	54.6	55.0	70.5	54.7	38.2
Franklin	35° 12′	83° 27′	2141	12	39.1	41.8	44.6	53.8	61.7	68.2	70.7	70.0	63.9	53.4	45.0	38.5	54.2	53.4	69.6	54.1	39.5
Highlands*	35° 5′	83° 25′	3817	15	33.5	36.6	41.6	50.6	57.5	64.7	67.1	65.4	60.2	51.0	42.2	36.0	50.4	49.9	65.7	51.1	35.4
Horse Cove*	35° 0′	83° 6′	2800	6	35.3	38.9	45.8	55.5	62.7	69.8	71.9	71.4	67.0	54.9	45.5	40.7	55.0	54.7	71.0	55.8	38.3
Hot Springs	35° 53′	82° 49′	1330	5	45.2	45.7	46.6	58.5	63.9	70.9	74.7	72.3	67.5	56.2	49.2	44.2	57.8	56.3	72.6	57.3	45.0
Linville*	36° 5′	81° 51′	3800	5	31.0	31.0	40.5	46.7	57.6	62.4	66.1	64.9	59.7	47.3	41.4	34.8	48.6	48.3	64.5	49.5	32.3
Lincolnton	35° 9	81° 12′	944	5	32.9	39.4	43.1	55.5	65.9	72.0	77.8	74.0	68.5	56.9	42.2	37.9	55.5	54.8	74.6	55.9	36.7
Lynn*	35° 12′	82° 14′	1500	9	36.8	41.6	49.4	59.3	64.2	72.5	74.9	73.1	68.1	55.9	47.0	38.5	56.7	57.6	73.5	57.0	38.8
Lenoir*	35° 58′	81° 30′	1186	26	36.4	40.4	45.9	56.8	64.0	71.4	74.4	73.2	65.8	56.1	45.4	38.5	55.7	55.6	73.0	55.8	38.4
Murphy	35° 8′	84° 0′	1614	12	39.6	41.9	47.2	55.7	64.0	70.0	73.7	71.4	65.9	54.4	45.1	38.6	55.6	55.6	71.7	55.1	40.0
Mt. Airy*	36° 30′	80° 40′	1048	10	35.9	39.9	44.7	55.7	64.1	72.0	74.8	73.1	67.9	54.3	46.4	39.6	55.7	54.8	73.3	56.2	38.5
Morganton*	35° 45′	81° 44′	1135	10	37.3	41.2	48.3	58.1	66.1	73.0	75.7	73.7	68.8	55.6	47.1	42.9	57.3	57.2	74.1	57.2	40.5
Mocksville*	35° 51′	80° 34′	651	5	38.3	42.3	51.7	60.2	68.4	74.1	77.3	76.0	72.0	58.8	51.6	43.8	59.5	60.1	75.8	60.8	41.5
Mt. Pleasant*	35° 28′	80° 28′	650	12	40.0	43.7	48.9	59.1	67.3	75.2	76.8	75.4	70.1	57.2	49.3	43.1	58.8	58.4	75.8	58.9	42.3
Marion*	35° 30′	82° 5′	1425	5	37.6	42.0	49.1	57.6	66.0	72.3	74.1	73.8	68.9	58.1	48.7	40.4	57.3	57.6	73.2	58.6	40.0
Statesville	35° 45′	80° 53′	950	12	36.0	40.4	46.0	57.1	65.4	72.7	77.1	75.8	68.4	55.8	44.9	35.9	56.3	56.2	75.2	56.4	37.4
Salisbury*	35° 40′	80° 29′	760	13	41.0	44.2	49.7	60.9	68.8	76.0	78.9	76.9	71.1	58.8	51.3	44.5	60.2	59.8	77.3	60.4	43.2
Waynesville*	35° 29′	82° 58′	2756	5	35.9	37.8	46.5	54.9	61.8	68.2	69.7	69.8	65.3	52.6	46.5	39.3	54.0	54.4	69.2	54.8	37.5
Webster	35° 20′	83° 17′	......	5	37.1	39.5	44.7	54.4	61.3	65.3	73.4	70.0	62.0	53.0	42.3	38.4	53.4	53.5	69.6	52.4	38.3
Averages for the State	......	......	......	*27	40.3	43.6	48.5	58.5	66.9	74.3	77.6	75.8	70.4	59.5	49.8	42.6	59.0	58.0	75.9	59.9	42.0

*Indicates that records were continued through 1897. Temperatures in Fahrenheit degrees.

TABLE II.—TEMPERATURE EXTREMES.

STATIONS.	Elevation, Feet.	Length of record, years.	Highest monthly mean.	Month. Year.	Lowest monthly mean.	Month. Year.	Highest observed.	Date.	Lowest observed.	Date.
Asheville	2250	23	74.8	July, 1879.	27.2	Jan., 1893.	95	Sept. 15, 1897.	*— 9	Jan. 16, 1893. Feb. 8, 1895.
Chapel Hill	500	41	82.2	July, 1893.	28.4	Jan., 1857.	105	Aug. 10, 1892.	— 1	Jan. 16, 1893.
Charlotte	808	22	82.6	July, 1881.	32.6	Jan., 1893.	103	July, 1879.	— 5	Dec., 1880.
Fayetteville	170	13	83.2	June, 1880.	34.2	Feb., 1895.	101	Aug. 9, 1896.	7	Feb. 8, 1895.
Greensboro	843	15	82.6	July, 1893.	32.3	Dec., 1876.	101	Aug. 10, 1896.	6	Jan. 28, 1897.
Highlands	3817	15	70.9	July, 1878.	24.4	Jan., 1893.	86	June, 1891.	—17	Feb. 8, 1895.
Horse Cove	2800	6	74.4	July, 1893.	28.5	Jan., 1893.	93	Sept. 15, 1897.	—13	Feb. 8, 1895.
Hatteras	11	23	79.6	July, 1883.	36.5	Jan., 1893.	92	Aug., 1883.	11	Feb. 8, 1895.
Kitty Hawk	9	23	83.7	Aug., 1888.	32.1	Jan., 1893.	107	July 18, 1887.	6	Feb. 8, 1895.
Littleton	380	7	80.0	July, 1893.	27.6	Jan., 1893.	104	Aug. 10, 1896.	— 4	Jan. 16, 1893.
Louisburg	375	7	79.6	July, 1893.	29.4	Jan., 1893.	103	Aug. 10, 1896.	— 5	Jan. 16, 1893.
Lenoir	1186	26	77.7	July, 1877.	27.3	Jan., 1893.	95	July 18, 1887.	—16	Dec., 1880.
Morganton	1135	10	80.0	July, 1868.	26.4	Jan., 1893.	100	Sept. 16, 1897.	— 1	Jan. 16, 1893.
Mt. Airy	1048	10	77.1	July, 1872.	26.2	Jan., 1893.	98	Sept. 28, 1891.	—15	Jan. 16, 1893.
Mt. Pleasant	650	12	79.1	Aug., 1896.	29.9	Jan., 1893.	98	June 29, 1889.	— 4	Jan. 21, 1893.
Murphy	1614	12	76.9	July, 1878.	28.5	Dec., 1876.	..	....	..	....
Newbern	12	21	83.8	July, 1887.	32.0	Jan., 1893.	100	Sept. 23. 1895.	6	Jan. 17, 1893.
Oak Ridge	885	8	79.0	Aug., 1896.	29.0	Feb., 1895.	99	June 4, 1895.	— 5	Jan. 14, 1893.
Pittsboro	480	9	79.0	July, 1896.	28.0	Jan., 1893.	97	June 2, 1895.	— 5	Jan. 17, 1893.
Raleigh	375	27	81.3	July, 1887.	30.8	Jan., 1893.	103	July 18, 1887.	2	Jan. 17, 1893.
Rockingham	210	5	82.1	July, 1893.	35.7	Jan., 1893.	103	Aug. 10, 1896.	— 2	Jan. 20, 1893.
Roxboro	600	5	79.8	July, 1893.	29.7	Jan., 1893.	100	Several dates.	— 4	Feb. 8, 1895.
Southport	34	42	83.3	July, 1872.	30.4	Jan., 1880.	103	July 12, 1879.	8	Jan. 12, 1886.
Salisbury	760	13	82.0	July, 1893.	33.0	Jan., 1893.	102	Aug. 10, 1896.	5	Feb., 21, 1896.
Selma	225	8	82.4	June, 1890.	29.9	Jan., 1893.	102	July 29, 1896.	— 5	Jan. 20, 1893.
Saxon	900	7	79.2	Aug., 1896.	26.8	Jan., 1893.	105	Aug. 9, 1896	— 8	Jan. 15, 1893.
Soapstone Mt.	900	9	78.6	July, 1893.	28.7	Jan., 1893.	99	Several dates.	— 9	Jan. 21, 1893.
Southern Pines	400	7	80.2	July, 1893.	33.7	Jan., 1893.	103	July, 1892. Sept., 1895.	5	Feb. 8, 1895.
Tarboro	50	12	81.2	July, 1893.	31.3	Jan., 1893.	105	Aug. 10, 1896.	— 1	Jan. 21, 1893.
Weldon	81	26	84.3	July, 1878.	28.2	Jan., 1893.	107	July, 1879. Aug., 1881.	— 9	Jan. 17, 1893.
Willeyton	45	8	78.6	July, 1896.	29.8	Jan., 1893.	99	July 18, 1890.	— 3	Jan. 21, 1893.
Wilmington	52	27	84.5	July, 1872.	37.4	Feb., 1895.	103	July 12, 1879.	10	Dec., 1880. Feb. 8, 1895.

* The minus sign (—) indicates temperatures below zero.

PRECIPITATION.

In the introduction to a paper on the rainfall of the United States (Bulletin D, issued by the Department of Agriculture, Weather Bureau) Mr. A. J. Henry states clearly the generally accepted theory of rainfall and the manner in which the operations are brought about in nature, as modified by various causes, all of which are admirably illustrated within the limits of North Carolina. Briefly, then, rain is caused by a sudden cooling of the air below the dew-point, resulting in the condensation of the moisture contained in it to the liquid state, and its final precipitation to the earth's surface. Mr. Henry names the following as the chief ways in which the ascensional movements of the air are produced: 1, the air may be forced up the side of a mountain into a region of diminished pressure and lower temperature; 2, the lower layers of the atmosphere under the influence of solar radiation frequently reach a state of unstable equilibrium inducing ascensional currents—summer thunderstorms are generally a result of this process; 3, lastly, the circulation of air in cyclonic storms, that is, a radial inflow from all sides and an ascensional movement from the center.

North Carolina belongs to that region of the United States east of the Rockies characterized by the largest precipitation, the center of which lies on the Gulf coast about the mouth of the Mississippi; there are, however, localities on the southeastern slope of the Blue Ridge which receive an annual rainfall not exceeded anywhere except on the coast of Washington and Oregon. The average rainfall for the state given by Prof. Kerr, 53 inches, is very nearly correct. The inclusion of the period 1892 to 1897, years noted for considerable deficiencies in precipitation, has reduced the normals at many points, and the annual total is now about 52 inches.

The averages for the three sections of the state are:

Eastern District	54 inches.
Central District	48 inches.
Western District	53 inches.

Considering the monthly averages, it is observed that the maximum rainfall occurs in July and August, with the chief minimum in October or November. The August average is 134, the October average 77 per cent. of the monthly normal. An abundance of waterpower in the rivers of the state is indicated by the copious rainfall and its fairly uniform distribution throughout the year.

In Table III (p. 36) is presented the average monthly, annual and seasonal precipitation at stations in North Carolina. It is to be observed that rainfall is a climatic factor subjected to far greater variations than temperature, and that a correspondingly longer series of years of observation is required to obtain correct normals. Strictly speaking, there is not a station in North Carolina with a series of rainfall observations long enough to afford a true normal. Mr. A. J. Henry has shown that at least 35 or 40 years of continuous observation are required to obtain a result that will not vary more than plus or minus 5 per cent. from the true normal. However, records for the past 15 to 25 years include very rainy and very dry years, and may certainly be considered as near the truth. The accompanying charts (figs. 2-6 inclusive) also show graphically the seasonal and annual precipitation in the state (see pp. 43-47).

The distribution of precipitation throughout the state may now be considered in greater detail. The point which attracts attention immediately is the belt of minimum precipitation through the central portion. The greater rainfall of the eastern division is produced by the proximity of the ocean, the larger amount in the west by the effect of elevation.

TABLE III.—TABLE OF AVERAGE MONTHLY AND SEASONAL PRECIPITATION AT STATIONS IN NORTH CAROLINA.

PRECIPITATION IN INCHES AND HUNDREDTHS.

EASTERN DISTRICT.	Latitude, ° ′	Longitude, ° ′	Elevation, ft.	Length of record, years.	MONTHLY AND ANNUAL PRECIPITATION.													SEASONAL PRECIPITATION.			
					Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Spring.	Summer.	Autumn.	Winter.
Beaufort*	34° 43′	76° 41′	13	3	2.60	3.38	4.96	3.56	2.91	3.96	4.86	3.68	3.36	5.48	2.65	5.35	46.75	11.43	12.50	11.49	11.33
Coinjock	36° 20′	75° 52′	20	6	2.79	2.23	4.28	4.38	2.20	3.45	6.27	7.06	5.42	2.20	3.03	2.96	46.27	10.86	16.78	10.65	7.98
Cape Lookout	34° 36	76° 36′	15	5	6.15	4.51	4.49	5.57	5.14	5.50	5.17	10.33	9.11	6.72	6.12	6.16	74.97	15.20	21.00	21.95	16.82
Edenton*	36° 3	76° 36′	30	5	3.16	4.47	3.83	2.55	7.14	3.43	5.19	3.40	3.19	4.89	2.76	3.21	47.22	13.52	12.02	10.84	10.84
Fort Macon	34° 42′	76° 40′	20	10	4.32	2.59	4.75	3.86	3.60	4.33	6.20	4.59	6.18	3.51	2.28	4.13	50.29	12.21	15.12	11.92	11.04
Goldsboro*	35° 23′	78° 00′	102	17	3.06	3.42	4.77	4.76	4.99	5.18	6.08	7.27	4.80	3.20	2.40	3.63	53.56	14.52	18.53	10.40	10.11
Greenville*	35° 38	77° 23′	75	9	3.77	2.89	4.65	4.49	3.88	4.00	5.09	7.10	5.00	3.31	2.57	3.13	49.88	13.02	16.19	10.88	9.79
Hatteras*	35° 15′	75° 40′	11	23	5.66	4.56	5.89	4.50	4.44	4.52	6.53	6.10	6.14	6.29	5.13	5.47	65.23	14.83	17.15	17.56	15.69
Kitty Hawk*	36° 0′	75° 42′	9	23	4.57	4.06	4.99	4.19	3.79	4.54	5.99	6.37	4.44	3.86	4.00	4.17	54.97	12.97	16.90	12.30	12.80
Littleton*	36° 26′	77° 54′	380	7	3.18	4.51	3.79	3.53	4.58	3.65	5.52	5.15	2.70	3.34	2.29	2.70	44.94	11.90	14.32	8.33	10.39
Lumberton*	34° 38′	78° 59′	...	10	5.20	3.90	3.56	3.56	4.27	5.71	5.81	6.52	3.93	3.46	2.13	1.80	49.85	11.39	18.04	9.52	10.90
Murfreesboro	36° 26′	77° 05′	75	5	2.88	3.40	2.80	4.00	3.68	2.84	5.29	3.10	2.80	2.05	2.79	3.05	38.68	10.48	11.23	7.64	9.33
New River Inlet	34° 32′	77° 18′	...	5	6.47	3.10	3.30	2.67	2.66	4.46	6.84	4.72	5.90	3.64	2.49	3.70	49.95	8.63	16.02	12.03	13.27
Newbern*	35° 6′	77° 02′	12	21	4.25	4.08	4.01	3.72	4.44	4.75	7.07	8.08	5.45	3.59	3.27	3.37	56.08	12.17	19.90	12.31	11.70
Norfolk, Va.*	36° 51′	76° 17′	69	27	3.67	3.88	4.48	3.87	4.40	4.28	5.91	5.81	4.43	3.99	3.07	3.65	51.44	12.75	16.00	11.49	11.20
Portsmouth	35° 2′	76° 4′	5	5	6.38	3.94	5.88	6.17	4.19	5.48	6.13	8.18	7.10	5.73	4.37	5.89	69.44	17.24	19.79	16.20	16.21
Southport*	33° 55′	78° 1′	34	22	3.91	3.41	3.86	2.63	3.27	4.00	6.72	5.56	5.84	4.57	2.94	3.11	49.32	9.76	16.28	12.85	10.43
Scotland Neck	36° 7′	77° 32′	50	10	3.86	3.34	3.83	4.10	3.59	2.79	5.48	6.96	6.49	2.23	3.40	3.99	50.06	11.52	15.23	12.12	11.19
Sloan*	34° 45′	77° 32′	50	5	3.31	4.41	4.06	3.51	4.09	4.88	6.15	7.45	3.87	4.90	2.39	3.15	52.17	11.66	18.48	11.16	10.87
Tarboro*	35° 50′	77° 35′	50	20	4.30	3.70	3.71	3.27	5.58	4.50	6.50	6.76	4.01	3.85	2.77	3.75	52.70	12.56	17.76	10.63	11.75
Weldon*	36° 24′	77° 32′	81	26	3.90	3.48	3.95	3.42	4.68	4.05	5.15	5.06	4.05	3.67	2.41	3.19	47.01	12.05	14.26	10.13	10.57
Willeyton*	36° 28′	76° 32′	45	8	2.80	3.87	3.67	2.87	5.00	5.13	6.65	5.54	3.25	3.83	2.53	2.77	47.91	11.54	17.32	9.61	9.44
Washwoods	36° 38′	75° 53′	10	5	4.39	3.82	4.10	2.14	3.17	4.44	3.91	5.20	2.14	2.73	1.71	3.01	40.76	9.41	13.55	6.58	11.22
Wilmington*	34° 14′	77° 57′	52	27	3.80	3.29	3.78	2.84	4.21	5.61	6.97	7.14	6.12	4.02	2.49	2.99	53.26	10.83	19.72	12.63	10.08

* Records continued during 1897.

TABLE III.—*Continued.*

CENTRAL DISTRICT.	Latitude, ° ′	Longitude, ° ′	Elevation, ft.	Length of record, years.	MONTHLY AND ANNUAL PRECIPITATION.													SEASONAL PRECIPITATION.			
					Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Spring.	Summer.	Autumn.	Winter.
Attaway Hill	35° 25′	80° 12′	850	11	3.70	4.50	5.41	4.52	4.65	4.67	4.20	5.09	4.90	3.35	3.02	3.72	51.78	14.58	13.96	11.27	11.92
Chapel Hill*	35° 54′	79° 4′	500	21	4.41	3.81	4.16	3.50	4.44	3.43	4.73	4.54	3.90	3.34	2.79	3.70	46.75	12.10	12.70	10.03	11.92
Fayetteville*	35° 6′	78° 53′	170	13	5.21	4.31	5.30	4.36	4.71	4.18	8.09	6.77	5.20	4.45	3.30	5.25	61.13	14.37	19.04	12.95	14.77
Greensboro*	36° 4′	79° 49′	843	5	2.09	4.00	3.80	2.93	4.69	5.31	5.26	4.18	3.98	3.55	3.29	2.71	45.79	11.42	14.75	10.82	8.80
Henderson*	36° 20′	78° 23′	490	5	3.96	4.31	3.98	5.19	4.98	3.82	6.15	3.79	3.16	4.15	2.60	3.19	49.28	14.15	13.76	9.91	11.46
Louisburg*	36° 7′	78° 18′	375	7	4.21	4.37	2.90	3.40	4.70	4.25	5.41	4.56	2.62	2.87	2.39	2.93	44.61	11.00	14.22	7.88	11.51
Moncure*	35° 39′	79° 0′	300	5	3.87	4.42	4.02	4.12	3.78	3.56	5.60	4.21	3.38	3.22	3.09	2.38	45.65	11.92	13.37	9.69	10.67
Monroe*	34° 59′	80° 34′	586	5	3.43	4.98	4.47	2.78	4.51	4.99	6.37	2.97	5.04	2.74	3.52	2.24	48.04	11.76	14.33	11.30	10.65
Oxford	36° 22′	78° 25′	475	7	3.73	4.33	3.13	2.66	6.03	3.40	4.73	4.91	3.49	3.22	3.01	2.31	44.95	11.82	13.04	9.72	10.37
Oak Ridge*	36° 10′	80° 0′	885	8	3.27	5.52	3.34	3.24	5.31	4.96	6.30	3.83	4.65	3.07	2.51	2.82	48.85	11.92	15.09	10.23	11.61
Pittsboro*	35° 42′	79° 12′	480	9	4.63	4.14	3.45	3.56	4.83	4.43	6.19	4.68	3.38	3.22	2.96	2.62	48.09	11.84	15.30	9.56	11.39
Roxboro*	36° 26′	78° 58′	600	5	3.63	4.88	3.06	2.91	4.91	3.26	6.34	3.78	4.24	3.25	2.86	2.69	45.83	10.88	13.38	10.37	11.20
Raleigh*	35° 45′	78° 37′	375	27	3.95	3.99	4.17	3.22	5.45	4.32	6.44	6.24	3.22	4.11	2.27	2.86	50.21	12.84	16.97	9.60	10.80
Rockingham*	34° 58′	79° 46′	210	5	3.87	4.61	3.28	3.05	3.56	4.63	6.98	6.58	3.46	3.18	2.68	3.34	49.22	9.89	18.19	9.32	11.82
Southern Pines*	35° 18′	79° 22′	400	7	4.06	4.36	4.37	3.62	4.68	4.59	8.23	6.63	2.54	3.13	2.47	3.01	51.69	12.67	19.45	8.14	11.43
Soapstone Mt.*	35° 46′	79° 37′	900	8	4.19	4.84	4.37	3.09	4.40	4.17	6.39	4.79	4.11	3.51	3.13	3.26	50.25	11.86	15.35	10.75	12.29
Selma*	35° 31′	78° 21′	225	8	3.03	4.37	4.76	3.49	4.82	4.12	6.23	7.10	2.92	2.98	2.45	3.40	49.67	13.07	17.45	8.35	10.80
Saxon*	36° 22′	80° 6′	900	7	3.44	4.59	2.98	3.02	5.00	4.99	4.41	4.97	4.21	2.49	3.17	2.27	45.54	11.00	14.37	9.87	10.30

* Records continued during 1897. Precipitation in inches and hundredths.

TABLE III.—*Continued.*

WESTERN DISTRICT.	Latitude, ° ′	Longitude, ° ′	Elevation, ft.	Length of record, years.	MONTHLY AND ANNUAL PRECIPITATION.													SEASONAL PRECIPITATION.			
					Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Spring.	Summer.	Autumn.	Winter.
Asheville*	35° 37′	82° 30′	2250	22	3.17	3.48	3.86	3.20	3.70	3.99	5.05	4.56	2.73	2.62	2.99	2.93	42.28	10.76	13.60	8.34	9.58
Bryson City*	35° 27′	83° 23′	..	10	4.70	5.73	5.32	3.78	4.02	4.01	5.49	4.91	3.26	2.44	3.51	3.18	50.35	13.12	14.41	9.21	13.61
Charlotte*	35° 13′	80° 51′	808	22	4.77	4.89	4.87	3.43	4.12	5.35	5.26	5.33	3.40	3.38	3.14	3.82	50.76	12.42	14.94	9.92	13.48
Flat Rock*	35° 15′	82° 25′	2214	5	3.87	4.74	3.60	5.02	4.79	4.85	7.21	5.42	5.49	4.43	4.44	5.61	59.47	13.41	17.48	14.36	14.22
Franklin	35° 12′	83° 27′	2141	12	5.96	6.97	6.42	4.28	2.99	4.40	5.10	5.35	3.98	3.48	3.66	4.52	57.11	13.69	14.85	11.12	17.45
Highlands*	35° 5′	83° 25′	3817	15	6.53	8.19	5.91	6.25	4.45	5.53	6.21	6.17	6.02	4.78	5.94	6.32	72.30	16.61	17.91	16.74	21.04
Horse Cove*	35° 0′	83° 6′	2800	6	7.76	6.95	5.13	6.42	4.85	8.29	7.68	7.11	5.83	2.31	5.37	5.28	72.98	16.40	23.08	13.51	19.99
Linville*	36° 5′	81° 51′	3800	5	4.08	4.08	4.45	5.26	4.49	4.86	8.29	3.76	4.59	1.86	5.58	5.60	56.90	14.20	16.91	12.03	13.76
Lincolnton	35° 9′	81° 12′	944	5	3.71	4.15	4.10	2.92	8.08	4.02	5.03	5.42	2.03	2.64	3.35	4.65	50.10	15.10	14.47	8.02	12.51
Lynn*	35° 12′	82° 14′	1500	5	3.93	5.62	3.98	5.45	4.78	5.23	4.66	5.47	4.05	4.13	4.84	3.42	55.55	14.21	15.36	13.01	12.97
Lenoir*	35° 58′	81° 30′	1186	28	4.17	4.45	4.00	3.58	4.74	4.15	5.06	5.61	4.67	3.29	3.31	3.68	50.74	12.32	14.85	11.27	12.30
Murphy*	35° 8′	84° 0′	1614	20	6.19	6.44	6.46	5.40	3.51	5.51	6.53	5.40	3.18	2.80	4.58	4.96	60.96	15.34	17.44	10.56	17.59
Mt. Airy*	36° 30′	80° 40′	1048	10	3.27	4.20	3.75	2.85	3.86	4.07	5.51	5.34	4.08	2.24	3.10	2.73	45.00	10.46	14.92	9.42	10.20
Morganton*	35° 45′	81° 44′	1135	10	3.96	4.70	3.43	4.03	3.79	3.98	4.88	3.84	5.02	3.00	3.31	2.59	46.53	11.25	12.70	11.33	11.25
Mocksville*	35° 51′	80° 34′	651	5	3.31	4.18	3.69	2.74	3.07	4.09	4.16	5.66	3.78	3.37	2.82	2.58	43.44	9.49	13.91	9.97	10.07
Mt. Pleasant	35° 28′	80° 28′	650	12	3.84	4.46	3.87	2.81	3.90	4.88	5.46	5.69	4.00	3.63	2.65	2.99	48.18	10.58	16.03	10.28	11.29
Mt. Holly	35° 24′	81° 3′	..	6	3.58	5.62	4.82	2.48	6.12	4.34	5.10	3.96	5.22	3.51	2.45	3.26	50.46	13.42	13.40	11.18	12.46
Marion*	35° 30′	82° 5′	1425	5	3.84	4.24	3.39	3.07	5.22	4.91	5.91	4.01	4.32	4.44	3.66	2.68	49.69	11.68	14.83	12.42	10.76
Statesville	35° 45′	80° 53′	950	12	4.75	4.50	5.36	3.19	5.24	4.64	5.38	5.66	2.66	3.66	2.84	3.69	51.57	13.79	15.68	9.16	12.94
Salisbury*	35° 40′	80° 29′	760	18	3.83	4.42	4.22	2.79	4.90	4.47	4.76	5.01	3.49	3.62	2.89	2.64	46.99	11.91	14.24	9.95	10.89
Webster	35° 20′	83° 17′	..	5	3.58	5.63	4.83	3.92	2.05	1.17	2.60	2.80	1.55	3.42	2.07	2.36	35.98	10.80	6.57	7.04	11.57
Waynesville*	35° 29′	82° 58′	2756	5	5.98	3.67	5.14	3.33	4.16	4.66	5.99	3.74	1.71	1.76	3.01	3.00	46.15	12.63	14.39	6.48	12.65
For the state				27*	4.35	4.21	4.56	3.77	4.21	4.37	5.58	5.78	4.42	3.57	3.32	3.73	51.87	12.54	15.73	11.31	12.29

* Records continued during 1897. Precipitation in inches and hundredths.

PRECIPITATION IN THE EASTERN DISTRICT.

The annual rainfall on the immediate coast, from Cape Hatteras to Cape Lookout, is over 60 inches; the amount gradually decreases westward to about 50 inches at Raleigh. Throughout the entire division the chief maximum rainfall occurs in July or August, the chief minimum in October or November, with a secondary minimum in April. In some years the chief maximum has been deferred to September or even October owing to the more frequent occurrence of sub-tropical storms during these months. The explanation of the greater rainfall in the east is very simple. The prevailing track of storms which cross North Carolina is from south to north, and the heaviest rainfall usually occurs on the east side of such storms. Thus it is inevitable that the circulation of the winds, while the storm is approaching or is over the state, will be such as to draw from the ocean large masses of damp, vapor-laden air, and that the greater amount of its moisture will fall in the east. The greater precipitation on the coast is not of much influence on waterpower, since it occurs only over the lower courses of the rivers.

PRECIPITATION IN THE CENTRAL DISTRICT.

The rainfall over the central portion of the state lies between 45 and 50 inches. This includes all points within the trapezoid formed by the northern and southern boundaries of the state and oblique lines drawn from Gates to Anson counties on the east and from Surry to Union on the west. The maximum fall occurs in July, and is almost entirely due to the convectional current inducted by solar radiation (thunderstorms). The amount of rainfall is nearly equal during spring and winter and is least in autumn.

PRECIPITATION IN THE WESTERN DISTRICT.

Great diversity characterizes this section. The rainfall is very great on the southeast slope of the Appalachians. In Macon county a series of very reliable observations at Highlands gives an annual normal of 72 inches, and an equally trustworthy record for six years at Horse Cove, south of and 1000 feet lower than Highlands, gives nearly 73 inches. The effect is due to the configuration of the valleys and the influence of elevation. When cyclonic disturbances pass westward of the state, or under any circumstances which will force masses of air against the mountains from the south, southeast or east, the currents of air are deflected upwards, and the moisture they contain is precipitated by the cold of elevation. The same effect is noticeable to a more limited extent on all of the eastern slopes of the mountains at least as far north as Linville, except where the ranges are lower. Immediately beyond the crest of the Blue Ridge there is a rapid diminution in the quantity of precipitation especially prominent in the larger valleys. Asheville, with a record extending over 22 years (which is broken, however, between 1880 and 1890), has a normal fall of about 42 inches, so far the smallest reliable record in the state; Waynesville, Haywood county, averages 46 inches. At many western stations the chief maximum falls in winter or early spring.

VARIATIONS IN PRECIPITATION.

Besides the abundant supply of water, the variations in the monthly and daily rainfall which change the amount of flow or volume of water carried to the sea are of considerable importance in considering the waterpower of a district. In Table IV (p. 48) are given for selected stations the largest and least monthly rainfall, with dates, and the possible fluctuations of the highest and lowest monthly averages in percentages of the monthly mean. In respect to the frequency of heavy rains North Carolina ranks very high. Considering an excessive daily fall to be 2.50 inches or more in 24 consecutive hours, in Septemeber the state ranks first in frequency of such rains, in August and October is surpassed only by Florida, in July and December by California, Louisiana and Texas. The least heavy precipitation occurs in June.

LARGEST DAILY RAINFALL.

The following are the largest daily totals ever recorded in North Carolina for each month of the year:

January.—Fayetteville, 6.00 inches, January 8 and 9, 1879.
February.—Highlands, 6.01 inches, February 8 and 9, 1891.
March.—Hatteras, 6.72 inches, March 30, 1879.
April.—Fayetteville, 6.25 inches, April 27 and 28, 1879.
May.—Weldon, 6.03 inches, May 10, 1887.
June.—Salisbury, 7.39 inches, June 10, 1883.
July.—Wilmington, 7.33 inches, July 15, 1886.
August.—Hatteras, 9.14 inches, August 23, 1880.
September.—Ellsworth, 13.00 inches, September 15 and 16, 1881.
October.—Columbus, 5.62 inches, October 13 and 14, 1893.
November.—Hatteras, 6.16 inches, November 7 and 8, 1893.
December.—Fayetteville, 6.00 inches, December 9th and 10th, 1878.

WET AND DRY YEARS.

The year 1877 was the wettest on record in North Carolina and during that year the highest stages ever known occurred in some of the rivers of the state. The annual rainfall has been below the normal continuously since 1889 (excepting a slight excess during 1891). The dryest years have been 1890, 1894, 1896 and 1897. It would probably surprise many people to learn that at four stations in North Carolina no measurable precipitation occurred in November, 1890, a possibility usually associated only with the arid regions of the west. The lowest stages of the rivers perhaps ever known occurred during the fall drought of 1897.

SNOWFALL IN NORTH CAROLINA.

The average snowfall for the state is about 5 inches. The snowfall is not a factor of great importance, as it is rarely heavy, and that which falls one day is generally dissipated by the next. In the mountains the snow rarely remains on the ground over a week at a time. There can be no accumulation of snow sufficient to cause spring floods as such. The heaviest snows frequently occur in the central section of the state, which is more open to the north and northeast winds accompanying storms on the coast with which snow usually occurs. During the past five years the snowfall in North Carolina has been much above the normal in consequence of the occurrence of two severe winters, one shortly after the other (1893 and 1895). The snowfall of February, 1895, was especially remarkable. The totals for that year were Littleton, 22 inches; Henderson, 32; Oak Ridge, 26; Saxon, 36; Asheville, 39; Highlands, 54; Linville, 48; Mt. Airy, 32; Lenoir, 22, and Waynesville, 34 inches.

The average annual snowfall at selected stations for the past five years is given below. These amounts are much above the normal annual fall:

Asheville	16	inches.
Chapel Hill	13	"
Highlands	22	"
Henderson	16	"
Littleton	16	"
Louisburg	15	"
Lenoir	11	"
Mt. Airy	12	"
Mt. Pleasant	11	"
Oak Ridge	11	"
Pittsboro	14	"
Raleigh	12	inches.
Roxboro	13	"
Rockingham	8	"
Southport	3	"
Selma	10	"
Saxon	17	"
Soapstone Mt.	17	"
Salisbury	11	"
Tarboro	7	"
Weldon	9	"

PRECIPITATION CHARTS.

The charts presented in Figures 2 to 6 are based on the material given in Table III (pp. 36-38). Records obtained previous to the year 1887 are not strictly comparable with those extending through 1897; and in some cases their proper weight has been estimated. It is to be observed, furthermore, that the scale of shading of necessity has not the same value in all the seasonal charts, beginning with a scale of 6 to 8 inches for autumn, 8 to 10 inches for spring and winter, and 12 to 14 inches for summer, the season of heaviest precipitation.

FRESHETS ON THE RIVERS.

All of the rivers of North Carolina are subject to freshets which occur irregularly at any time of the year. The melting of snow in the mountains and breaking up of ice in spring are never a cause of freshets in this state. Ice gorges occasionally occur in the western rivers, especially on the New river and its tributaries. Freshets may take place in a single river basin, as for instance, in August, 1894, when heavy rains occurred in the southeast portion of the state from the 3d to the 6th, which caused a rapid rise in the Cape Fear river to 34 feet on the gauge at Fayetteville, while streams further north were not affected at all. The most disastrous flood of recent years was that of July, 1896, when the Roanoke reached 42 feet at Weldon (within 5 feet of the highest stage known) and the Cape Fear 49.5 feet on the 12th. Probably the highest authentic stage known on the Cape Fear was 58 feet, January 12, 1895.

INFLUENCE OF RAINFALL ON THE FLOW OF STREAMS.

In conclusion, it may be noted that the calculation of the amount of water available for power from a given rainfall is a very complicated one. While rivers draw their entire supply of water from the precipitation over their basins, a large percentage of the rainfall is lost immediately by evaporation, absorption by vegetation, etc., and much soaks into the ground until it reaches an impervious substratum. The river supply is sustained during drought by the underground waters. There will be, then, a very great variation in the influence of rainfall at different seasons of the year. The following illustration may be given as an extreme case.

The mean stage of the Cape Fear river at Fayetteville during December, 1894, was 7 feet, and the final stage, December 31, 6 feet. The average rainfall over the entire basin of the river during January, 1895, was 6.97 inches, which maintained during January a mean stage of 20 feet, and caused a maximum flood of 58 feet on the 12th.

Consider, now, similar data for August, 1898. The mean stage during July, 1898, was 6 feet, the final stage 4 feet, which, though 2 feet lower than that at the end of December, 1894, is not material at such

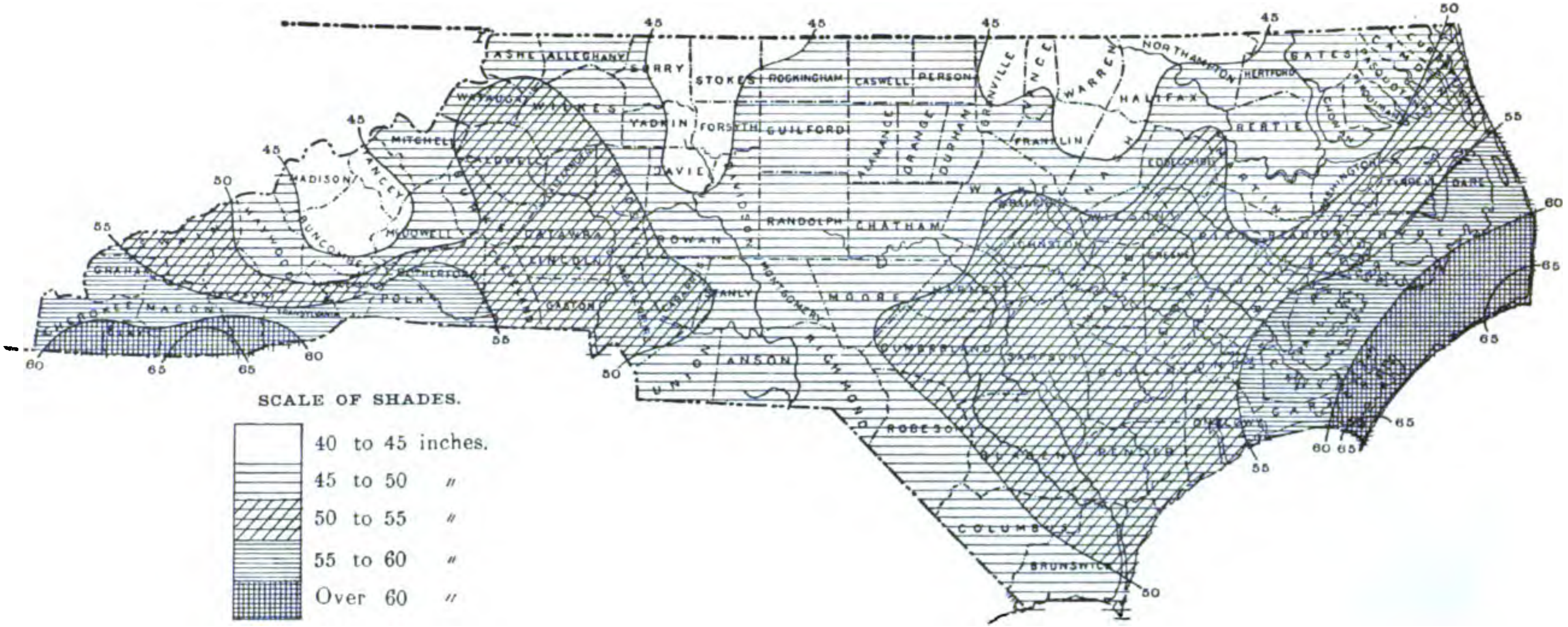

FIG. 2.—CHART SHOWING THE MEAN ANNUAL PRECIPITATION IN NORTH CAROLINA IN INCHES. (SEE P. 41.)

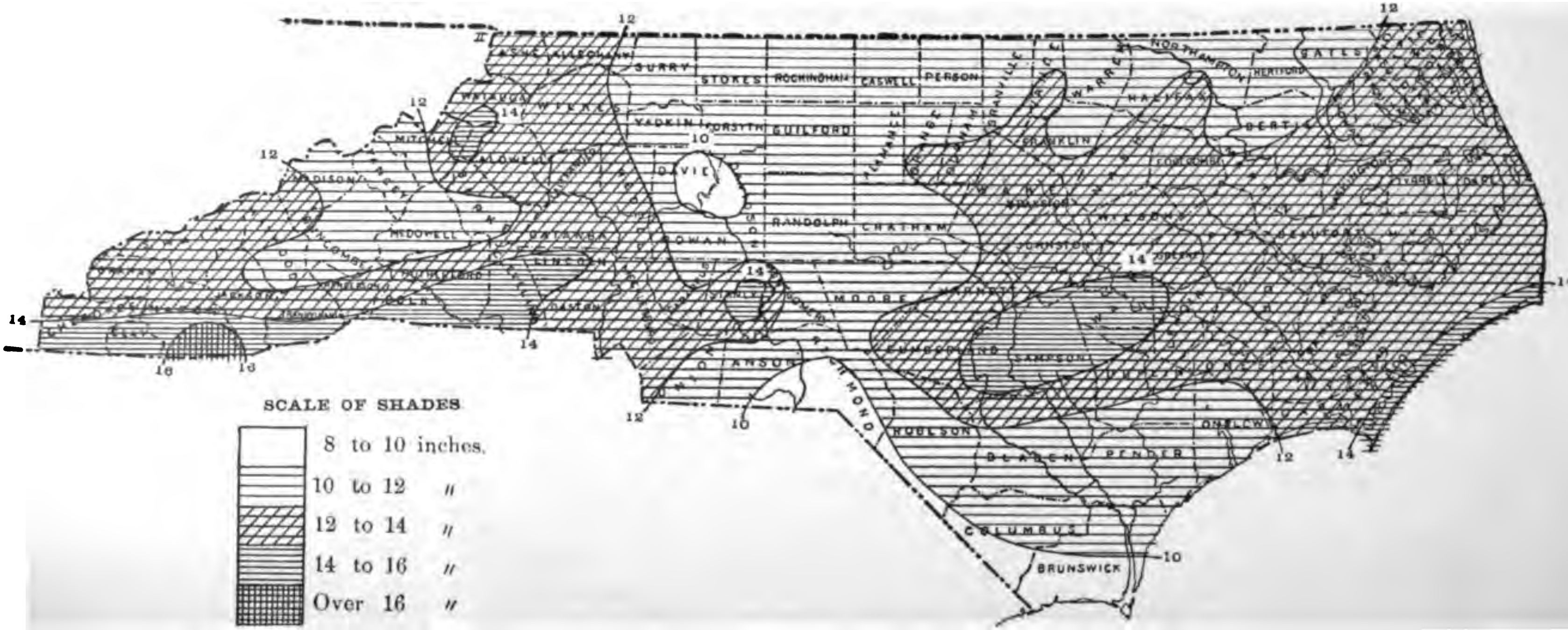

FIG. 3.—MEAN PRECIPITATION IN NORTH CAROLINA DURING THE SPRING. (SEE P. 41.)

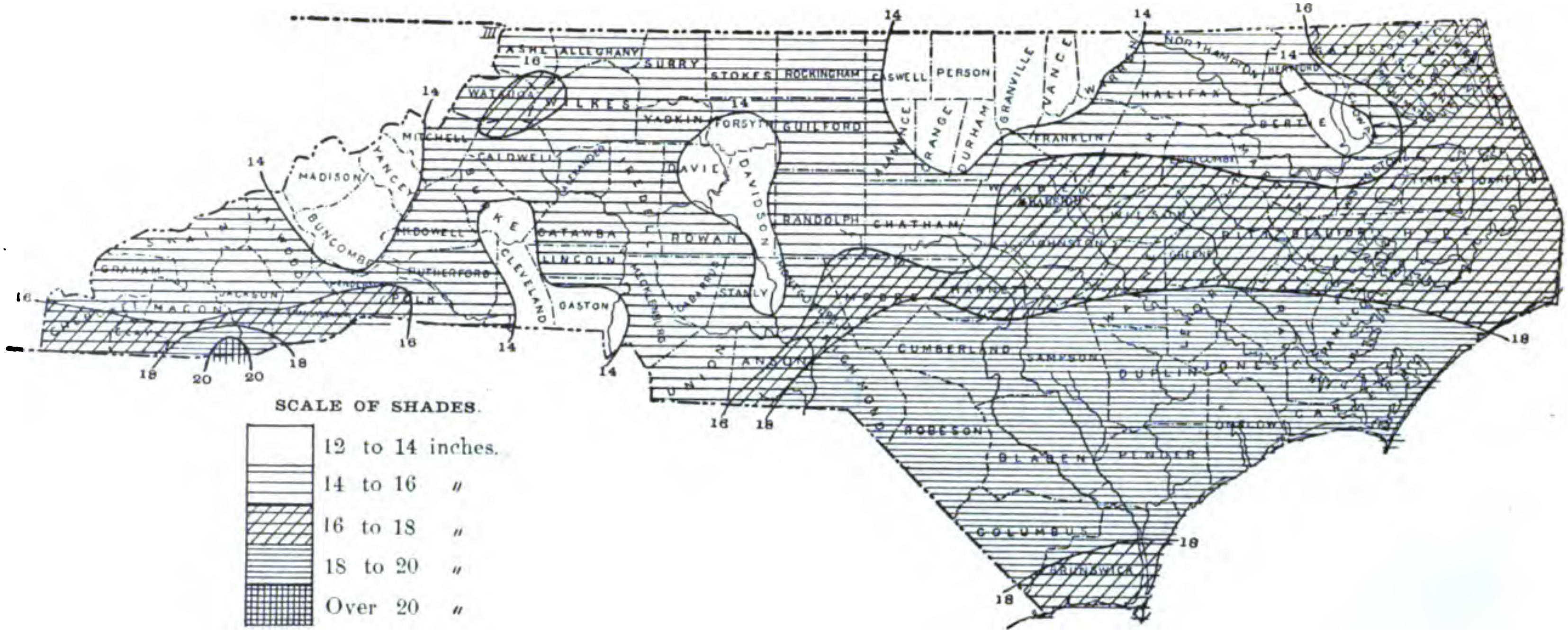

FIG. 4.—MEAN PRECIPITATION IN NORTH CAROLINA DURING THE SUMMER. (SEE P. 41.)

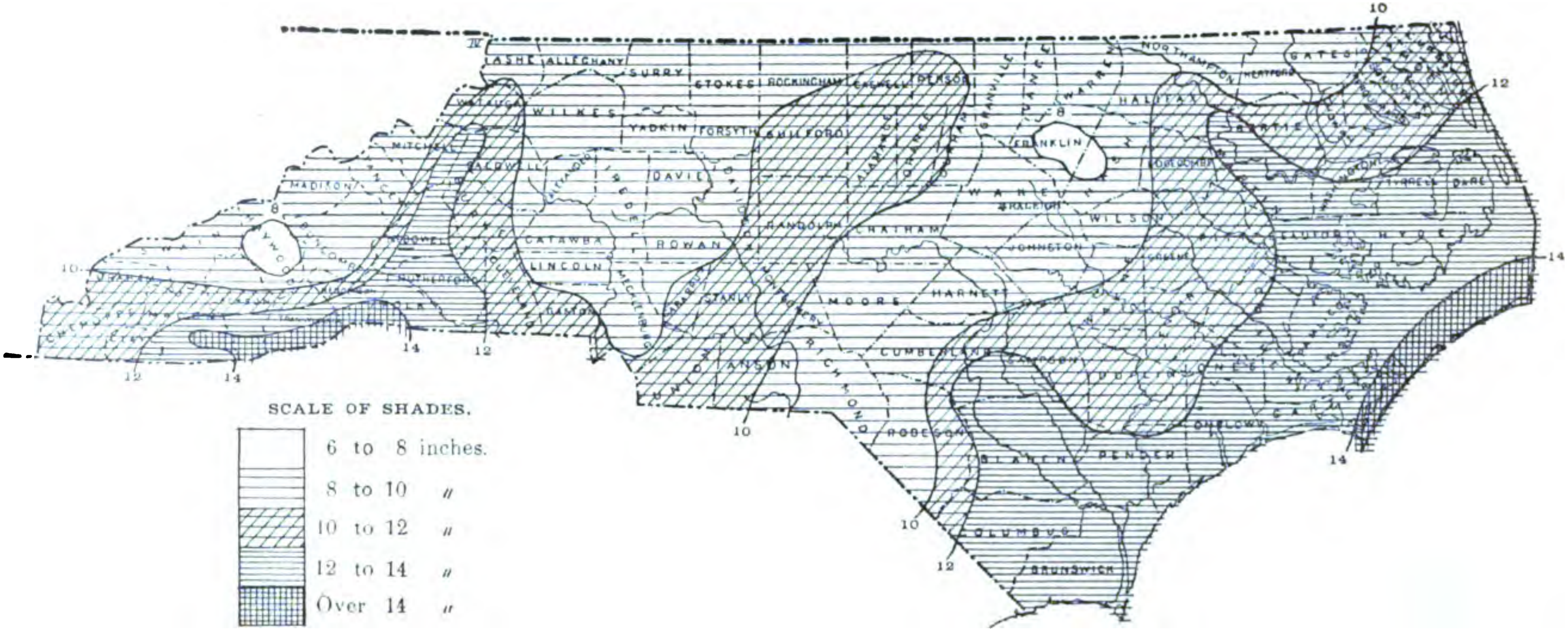

FIG. 5.—MEAN PRECIPITATION IN NORTH CAROLINA DURING THE AUTUMN. (SEE P. 41.)

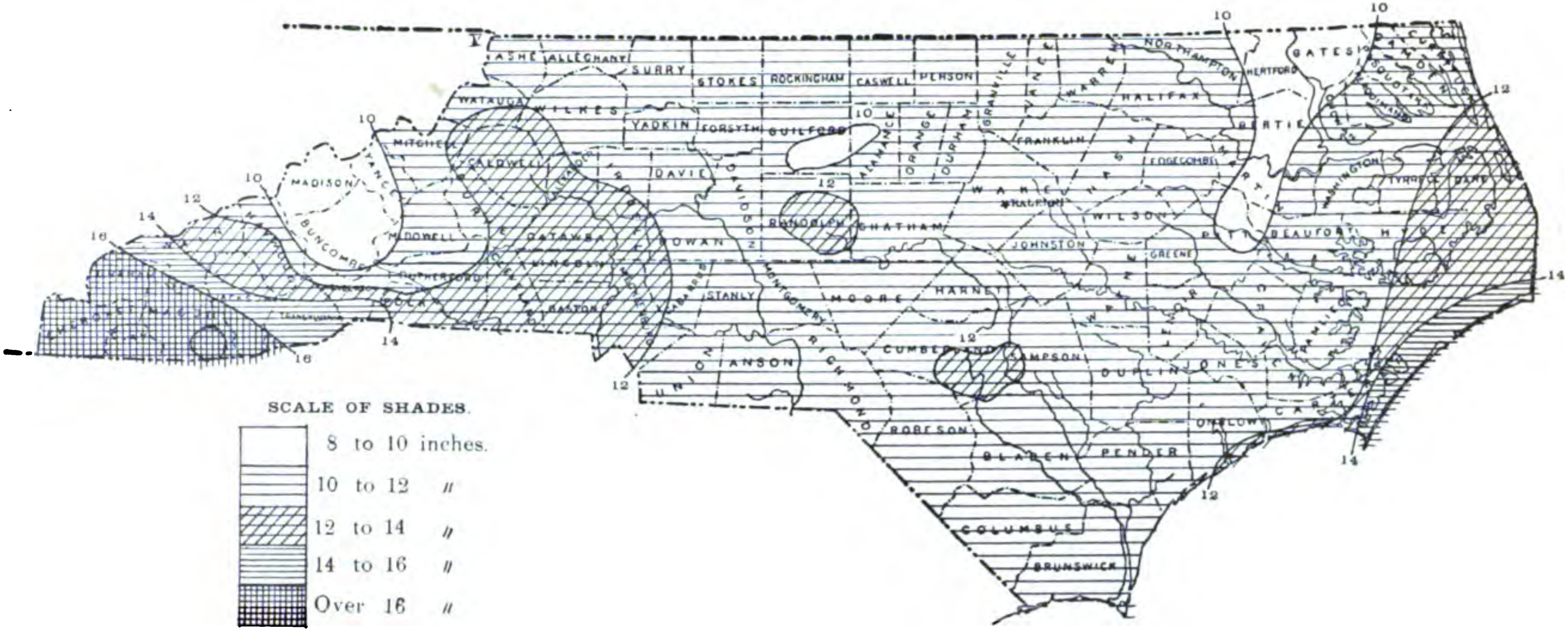

FIG. 6.—MEAN PRECIPITATION IN NORTH CAROLINA DURING THE WINTER. (SEE P. 41.)

low stages. The average rainfall for August over the entire basin was 7.59 inches, or over half an inch more than during January, 1895, yet this amount was only able to maintain a mean stage during August of 10 feet at Fayetteville, and the maximum flood was only 29 feet on the 22.

Waterpower depends on the quantity of water in cubic feet per second and the distance through which that water falls. From the data furnished by the meteorologist, and his own measurements on the volume and fall of streams, it is the province of the hydraulic engineer to calculate the available waterpower.

TABLE IV.—GREATEST AND LEAST MONTHLY PRECIPITATION.

STATIONS.	Elevation, feet.	Length of record, years.	Greatest monthly. (Inches).	Month and Year.	Least monthly. (Inches).	Month and Year.	Highest and Lowest monthly averages in percentages.[1]	
Asheville	2250	23	11.40[2]	July, 1874	0.21	Oct., 1895	143	74
Chapel Hill	500	41	11.71	Aug., 1891	trace	Nov., 1890	121	86
Charlotte	808	22	11.13	Mar., 1891	0.23	Nov., 1890	126	74
Fayetteville	170	13	17.20	July, 1879	0.34	Oct., 1892	159	65
Goldsboro	102	21	16.70	Sep., 1877	0.35	Oct., 1886	163	54
Greensboro	843	15	10.75	Aug., 1893	0.23	Sep., 1895	139	55
Greenville	75	9	15.10	Sep., 1877	0.35	Nov., 1879	171	62
Highlands	3817	15	20.20	Feb., 1891	0.25	May, 1883	135	79
Horse Cove	2800	6	17.02	Jun., 1892	0.62	Oct., 1892	136	38
Hatteras	11	23	16.30	Aug., 1880	trace	Nov., 1890	120	80
Kitty Hawk	9	23	15.36	July, 1882	0.05	Sep., 1895	139	83
Littleton	380	7	10.29	Aug., 1891	0.25	Sep., 1897	148	61
Louisburg	375	7	8.49	Aug., 1891	0.36	Oct., 1892	145	64
Lenoir	1186	26	11.50	May, 1873	0.00	Nov., 1890	133	78
Lumberton	....	10	12.50	Sep., 1883	0.11	Oct., 1884	157	44
Morganton	1135	10	11.20	Apr., 1878	0.20	Oct., 1892	129	67
Mt. Airy	1048	10	10.38	July, 1889	0.17	Nov., 1890	147	60
Mt. Pleasant	650	12	10.27	Aug., 1887	0.28	Oct., 1892	142	66
Newbern	12	21	19.65	Aug., 1878	0.20	Nov., 1890	178	70
Oak Ridge	885	8	10.99	July, 1891	trace	Nov., 1890	155	62
Pittsboro	480	9	13.40	Apr., 1895	0.01	Oct., 1892	154	65
Raleigh	375	27	11.23	July, 1890	0.06	Nov., 1890	154	54
Rockingham	210	5	10.16	Aug., 1893	0.37	Oct., 1892	170	65
Roxboro	600	5	12.56	July, 1896	0.36	Oct., 1896	166	70
Southport	34	42	12.53	Aug., 1887	0.10	Dec., 1889	164	64
Salisbury	760	13	16.14	Aug., 1887	0.18	Nov., 1890	128	67
Selma	225	8	16.30	Aug., 1891	0.20	Nov., 1890	171	59
Saxon	900	7	10.87	Aug., 1893	0.58	Dec., 1896	132	60
Soapstone Mount	900	9	10.50	Mar., 1891	0.25	Nov., 1890	153	74
Southern Pines	400	7	11.08	May, 1891	0.11	Sep., 1895	191	57
Tarboro	50	12	22.73	Aug., 1887	0.10	Sep., 1895	154	63
Weldon	81	26	10.56	Sep., 1888	0.05	Nov., 1890	160	62
Willeyton	45	8	10.72	Aug., 1890	0.25	Nov., 1890	167	63
Wilmington	52	27	21.12	July, 1886	0.19	Nov., 1886	161	56

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[1] Explanation.—The highest and lowest monthly average rainfall from Table III, in percentages of the mean, obtained by dividing the annual total by 12. Thus, annual rainfall at Asheville (Table III), 42.28 divided by 12 — 3.52 inches. Of this the largest monthly average at Asheville, 5.05 in July, is 143 per cent.; the smallest monthly average, 2.62 in October, is 74 per cent.

[2] A larger record exists, which is not considered quite trustworthy.

CHAPTER III.

THE FLOW OF STREAMS.[1]

The essential elements of a waterpower are the fall and the quantity of water; and the amount of fall being a fixed quantity, capable of being measured once for all, and therefore not needing discussion, it is necessary to determine the amount of water that a given stream will afford at a certain point and the variation in the flow from month to month.

CONDITIONS AFFECTING THE FLOW.

The average amount of water carried past a certain point in a year depends, among other things, upon the amount and distribution of the rainfall, the area of the drainage-basin, and the character of that basin. All the water carried by is derived from the rainfall, but of the total rainfall a certain amount is lost in the following ways: By percolation and discharge through subterranean channels; by evaporation from the soil and the surfaces of streams; by absorption through the roots of trees, shrubs, and grasses, and subsequent evaporation. The amount discharged by the streams will be greater as these sources of loss are diminished, and the problem before us is to determine for each particular case what proportion of the rainfall is so discharged; and we must, moreover, endeavor to find out the laws regulating the distribution of the flow through the year, and from year to year. In the case of most streams the flow varies greatly from day to day, and from month to month, being occasionally in times of freshet 50, 100, and even several hundred times its minimum volume. Thus the table given further on shows that the Potomac river at Cumberland has been known to discharge a quantity 716 times as great as its minimum discharge, while the maximum discharge of the Merrimac is only about 70 times its minimum discharge.

A great fluctuation in the volume of water in a stream is evidently an obstacle to the extensive use of waterpower, making it necessary to depend only on the flow at times when the stream is low, or to use auxiliary steam power, or to store the freshet water in reservoirs, and so increase the flow in dry seasons. It is necessary, therefore, to discuss, to some extent, the total amount discharged by streams (or the proportion of the rainfall flowing off) and the manner in which that total amount is distributed through the year. As regards the first of these questions, it has generally been customary to assume a certain fixed proportion of the annual rainfall as flowing from the surface and discharged by the streams; but it has always been recognized that the proportion to be thus assumed varies greatly according to numerous circumstances, such as the area and form of the drainage-basin; the distribution of the rainfall through the year, as well as its amount; the extent of the forests; the number and extent of lakes; the character of the soil and rocks, and the state of cultivation; and all of these factors affect not only the total discharge of a stream but also its distribution. With a given watershed, in any particular year, a certain proportion of the rainfall will be discharged and distributed in a certain way, but both that proportion and that distribution are liable to change if any one of the above conditions are altered. Thus the greater the area of the watershed the more uniform the flow, other things equal, because streams draining small areas are more subject to the effects of sudden rains than those draining large ones; and while in the former case there may be weeks at a time when no rain falls on the basin, and the stream draining it almost dries up, in the latter case there will probably be frequent rains on some part or other of the basin.

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[1] By Geo. F. Swain, Professor of Civil Engineering in the Mass. Institute of Technology, Boston.

The table given further on illustrates this point by showing that, as a rule, the ratio of maximum to minimum discharge is greater in the case of small streams than in that of large ones. And, in like manner, the form of the drainage basin exerts a certain influence. The distribution of the rainfall is a very important point, and as an example of the great variability of the proportion of the rainfall discharged from the same watershed in different years the case of the drainage area of the Albany waterworks may be cited, where, from an area of 2,600 acres in 1850, between May and October, inclusive, 41½ per cent. of the rainfall was carried off by the streams, while in 1851, within the same period (from May to October) 82.6 per cent. was discharged.[1] Hence it is that the year of minimum rainfall may not be the year in which the streams get lowest, or the one in which the season of lowest flow occurs. An eminent authority has remarked: "This (the year with the season of least flow) is not necessarily the year of least rainfall, nor even the year of greatest apparent drought, but is the result of such a distribution of the rainfall that the excess of water over the amount needed for sustaining vegetation and supplying losses by evaporation is very small for several successive months."[1] The proportion of the rainfall discharged by streams is therefore a very uncertain and variable quantity, varying not only for different streams, but for the same stream in different years; and it is evident that the attempt to deduce the distribution of the flow of streams by taking certain proportions based on the rainfall is still more uncertain. Hence it is that some eminent engineers have given up the use of any proportion at all in calculations regarding the capacity of streams to furnish water-supply, and have adopted for this climate a certain fixed number of inches of rainfall as available. Mr. Croes has remarked in another place[2] that "the few records that exist of the flow from known drainage areas establish the fact that not over 15 inches per annum can be depended upon on the Atlantic slope, and many engineers who have devoted a good deal of attention to the subject are very decided in their opinion that not more than 11 inches should in any case be calculated on."

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[1] Hughes, *Waterworks*, p. 332.

Extended data with reference to the amount of water available from watersheds is obtainable in connection with certain New England streams, and the following figures may be of interest, although not applicable to streams in other parts of the country where the conditions are different.

On the Cochituate watershed near Boston, comprising an area of about 19 square miles, the average rainfall is 47.43 inches and the average amount collected is 21.59 inches, or 45 per cent. In 1880, however, the rainfall was 35.83 inches, the amount collected 10.3 inches, or 29 per cent., while in 1883 the rainfall was 31.2 inches, the amount collected 10.11 inches, or 32 per cent. On the Sudbury watershed, which also supplies Boston, and comprises about 75 square miles, the average rainfall is 45.75 inches, the average "run-off" 22.29 inches, or 48 per cent. In 1880, the rainfall was 38.18 inches and the "run-off" was 12.18 inches, or about 32 per cent.; and in 1883 the rainfall was 32.78 inches, the "run-off" 11.19 inches, or 34 per cent. In these cases the minimum "run-off" is about one-half the average. In the cases of larger watersheds the difference will not be so great.

The annual yield of streams, or, as it is frequently called, the "run-off," is now being studied in the case of many streams in all parts of the country, and in the near future better results than are now available will be at the disposal of hydraulic engineers. The U. S. Geological Survey is doing much in this direction, and in one of its bulletins (Bulletin No. 140, 1896) much information is given in this connection. Regarding large streams, however, the details are comparatively meagre, and in few cases have the records been long enough continued to allow reliable estimates for the future to be made. In New England, the Merrimac and Connecticut rivers are daily measured in connection with the large waterpowers developed at Lawrence, Lowell and Holyoke, but these streams are exceptional and are no criterions in judging of the streams in the Southern states, principally because they are fed by many or by large lakes. It may be mentioned, however, that even the Connecticut river, with an average rainfall of about 44 inches and a drainage basin of 8,660 square miles, has in one year (1883) shown as low a "run-off" as 12.7 inches.

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[1] Newark Aqueduct Board, Report on Additional Water Supply, by J. J. R. Croes and G. W. Howell, 1879.

[2] *Engineering News*, March 20, 1880, p. 104.

Measurements have been made, by the Geological Survey, of the flow of various streams in North Carolina. The results are interesting, but the measurements do not cover sufficient time to be of much service in connection with the estimates in this report. When extended so as to cover twenty or thirty years, these records will be of great value.

CONDITIONS AFFECTING FLUCTUATIONS IN FLOW OF STREAMS.

It may not be out of place to devote a few lines here to a closer consideration of the causes affecting the fluctuations in the flow of streams. Evaporation, the principal source of loss, acts in different months with very different degrees of intensity, being generally greatest in the summer months and least in the winter. It is sometimes the custom, in calculating the amount of water-supply available for the use of a town, to assume a certain proportion of the rainfall of each month as collectible or as discharged through the streams, that proportion varying from 20 or 30 per cent. in summer months to 70 or 80 per cent., or even over 100 per cent., in others. Now, if we assume that the rainfall at any particular time reaches the streams within a short time after it has fallen, say within a month or so, then, if the rainfall is uniformly distributed throughout the year, the flow of the streams will decrease as the evaporation increases, and will be several times greater in some month (the month of maximum flow) than in some other month (the month of minimum flow). If, now, the rainfall be so distributed that in the months when the evaporation is *least* the greatest rainfall occurs, it is evident that the proportion of the rainfall discharged will be greater than in the first case, while the variability of the flow will also be greater. In this case, then, a larger amount of water will be available, but the storage necessary will also be larger, while the minimum and low-season flow of the stream, without storage, will be less than before, for the reason that the minimum rainfall will occur during the summer months, when the evaporation will be greatest.

Again, if the greatest rainfall occurs in those months in which the evaporation is greatest, the proportion of the rainfall discharged by the streams will be less than in the first case, but the flow will be more uniform. In this case, then, a smaller amount of water will be available, but the necessary storage will be less, while the minimum flow of the stream, without storage, will be greater than in either of the previous cases. Hence we see how the distribution of the rainfall and the amount of the evaporation affect the flow of the streams, and by considering these, as well as the other elements affecting waterpower, we may be able to judge of the relative value of two streams, and to form some estimate of their flow, even if no gaugings are at hand, although such estimates are very rough and liable to be greatly in error.

CONDITIONS AFFECTING UNIFORMITY OF FLOW.

Two elements of a good waterpower are large flow, or large proportion of rainfall available, and uniform flow. The flow may be large, but if it is very variable the storage-room necessary to utilize it all may be too large, while a small flow, if uniform, could be utilized without any storage at all (except where it is desired to concentrate the power into less than twenty-four hours). But the remaining factors above named, viz. soil, forests, lakes, affect very materially the flow of streams, both in amount and in constancy. The effect of these is felt in so many ways that it would not be the place here to discuss them extensively. But, as showing what principles have guided me in making my estimates of the flow of the various streams, I may be permitted to sum up here briefly these effects.

A deep and porous soil, if underlaid by an impervious stratum, down to which the streams have cut their beds, has the effect of diminishing the evaporation and rendering the flow of the streams more constant. In some cases, however, and especially when the streams have not cut down to an impervious bed (that sheds the water that percolates to it), a deep and pervious soil is accompanied by considerable loss by flowage in subterranean courses, so that the flow of the streams may be diminished. It does not seem as though this were the case in the Southern states.

The action of lakes in regulating flow is evident, but it is next to impossible to estimate it numerically. They exert a more important influence in this respect than any other factor entering into the question.

As regards forests, I am constrained to speak of their action somewhat briefly, for the reason that the problem is one of great complexity and involves many factors which are at present not well understood, and because of the further fact that, on account of the climatic conditions in some parts of the district under consideration, their influence may be overestimated. Although authorities are not agreed as to whether forests increase the actual amount of rainfall, the weight of evidence seems to be tending to prove that they do not. All are agreed, however, that they act as regulators of the flow of streams; which they appear to accomplish through the decreased evaporation under a shaded surface, and the increased sub-drainage through the resistance to surface drainage and increased porosity of a forest-covered soil. The forests, therefore, diminish the quantity of water flowing directly from the surface in summer, and by storing it up, to be given out gradually, contribute to the constancy of the streams. (See page 64 for further remarks.)

METHOD OF ESTIMATING THE FLOW OF STREAMS.

I will now proceed to explain the general method I have followed in estimating the flow of the streams in this district. In calculating the amount of waterpower available I have considered the flow of streams chiefly with reference to three quantities, viz.:

1. The absolute minimum flow.
2. The minimum low-season flow.
3. The low-season flow in ordinarily dry years, but not the driest.

a. THE ABSOLUTE MINIMUM FLOW determines the maximum power which the stream will afford, at a given point, *at all times;* but as this minimum flow generally occurs during a period of not over a few days at intervals of a number of years, it is not of so much importance as the other quantities, and if only this flow is utilized there will be a large amount of water wasting, even in the low season, for years in succession. The amount of this flow is best approximated to, by assuming a certain discharge per square mile of watershed, varying with the area of the watershed and the local and climatic conditions. In estimating this flow I have made use of the results given in the table on page 55.

TABLE SHOWING EXTREMES OF FLOW FOR SOME AMERICAN STREAMS.

RIVER.	PLACE.	Drainage area, square miles.	MEAN RAINFALL, INCHES. Spring.	Summer.	Autumn.	Winter.	Year.	REMARKS ON CHARACTER OF DRAINAGE BASIN.	EXTREMES OF FLOW. Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.	Minimum cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second per square mile.	AUTHORITY AND REMARKS.
Merrimack...	Lowell	4,085.00	10	11	13	9	43	Lakes and artificial reservoirs. Wooded.	81,000	1,275.00	64	0.31	......	J. B. Francis and others.
Merrimack...	Lawrence.........	4,599.00	10	11	13	9	43	Lakes and artificial reservoirs. Wooded.	96,000	1,400.00	69	0.30	0.60	Private information.
Concord	Lowell	361.00	11	11	12	10	44	Hilly and swampy	4,449	60.00	74	0.170	0.35	C. Herschel.
Sudbury	Framingham	78.00	11	11	12	10	44	Hilly and swampy. One-sixth to one-eighth wooded.	3,228	2.80	1,153	0.036	0.16	A. Fteley.
Charles	....	215.00	11	11	12	10	44	Hilly and rolling........	....	44.00	......	0.20	......	Mass. State Bd. of Health, 1879.
Hale's Brook, Mass.	....	24.00	11	11	12	10	44	....	....	3.24	......	0.135	......	J. P. Frizell.
Connecticut..	Hartford...........	10,154.00	10	12	12	10	44	Numerous lakes and artificial reservoirs. Wooded. Mountainous in parts.	205,464	5,208.00	40	0.513	......	T. G. Ellis. (Of late years the flow has been much lower.)
Connecticut..	Hanover, N. H.....	3,316.00	10	12	12	10	44	Numerous lakes and artificial reservoirs. Wooded. Mountainous in parts.	....	1,006.00	......	0.306	0.365	Prof. Robt. Fletcher.
Housatonic...	Kent, Conn........	758.00	12	12	12	10	46	Hilly. Many ponds and reservoirs.	....	....	......	0.165	......	Measurements only one year. Trans. A. S. C. E., 1879.
"	Birmingham, ... Conn.	1,562.00	12	12	12	10	46		....	500.00	......	0.32	......	
Croton	....	339.00	12	13	13	10	48	....	25,380	60.00	423	0.178	......	J. J. R. Croes. Measurements about 1867-70.
W. Br. Croton	....	20.37	12	13	13	10	48	....	1,109	0.33	3,307	0.016	......	J. J. R. Croes.
Passaic	Paterson, N. J.. .	813.00	12	14	12	10	48	Some lakes and swamps. Hilly.	17,913	195.00	92	0.24	......	J. J. R. Croes and G. W. Howell.
Delaware.....	Lambertville	6,820.0±	11	13	11	9	44	Hilly and rolling. Many lakes. Well wooded.	350,000	2,000.00	175	0.29	......	Ashbel Welch.

TABLE SHOWING EXTREMES OF FLOW FOR SOME AMERICAN STREAMS.—*Continued.*

RIVER.	PLACE.	Drainage area, square miles.	MEAN RAINFALL, INCHES.					REMARKS ON CHARACTER OF DRAINAGE BASIN.	EXTREMES OF FLOW.			Minimum, cubic feet per second per square mile.	Ordinary low-water flow, cubic feet per second per square mile.	AUTHORITY AND REMARKS.
			Spring.	Summer.	Autumn.	Winter.	Year.		Maximum, cubic feet per second.	Minimum, cubic feet per second.	Ratio.			
Schuylkill	Philadelphia	1,912.00	12	14	10	9	45	Hilly and rolling. No lakes. Some reservoirs.	....	310.00	......	0.16	......	H. P. M. Birkinbine.
Ohio	Pittsburg	18,732.00	10	12	9	10	41	Hilly and mountainous. No lakes. Wooded.	....	2,271.00	......	0.12	......	J. H. Harlow.
Potomac	Cumberland	920.00	10	12	9	8	39	Narrow valleys. Steep slopes. Wooded. No lakes.	17,900	25.00	716	0.022	......	W. R. Hutton.
Potomac	Dam No. 5	5,066.0±	11	12	9	8	40	Narrow valleys. Steep slopes. Wooded. No lakes.	92,772	363.00	255	0.078	......	W. R. Hutton.
Potomac	Great Falls	11,476.00	12	13	9	8	42	Country more open. No lakes.	175,000	1,063.00	165	0.093	......	W. R. Hutton.
Rock Creek	Hoyle's Mill	64.40	11	12	11	8	42	....	9,800+	750.00	1,307	0.114	0.455	Quoted by W.R.Hutton.
Kanawha	Charleston Pool	8,900.00	12	13	9	10	44	Mountainous. Steep. No lakes. Wooded.	120,000±	1,100.00	110	0.123	......	Gill, Scott, and Hutton.
Greenbriar	Mouth of Howards creek.	870.00	11	12	8	9	40	Mountainous. Steep. No lakes. Wooded.	....	97.00	......	0.120	......	McNeill.
Shenandoah	Near Port Republic.	770.00	12	13	8	8	41	Hilly. Limestone. No lakes. Many springs.	....	128.00	......	0.167	......	James Herron.
James	Richmond	6,800.00	12	12	9	10	43	Mountainous in upper part. No lakes. Wooded.	....	[1]1,300.0+	......	0.191	......	H. D. Whitcomb and W. E. Cutshaw.
Neuse	Near Raleigh	1,000.00	12	14	10	11	47	Open. Clay and loam. No lakes. Few extensive woods.	....	....	......	......	0.193	W. C. Kerr, "low water."
Wisconsin	Portage, Wis.	8,200.00	9	12	9	5	35	Prairie	....	2,800.00	......	0.34	......	Report Ch. Eng. U. S. A., 1875.
Minnesota	Mouth	17,230.00	65	11	5.5	3	26	"	....	1,155.00	......	0.067	......	Ditto.
Illinois	Mouth	29,013.00	11	11	9	8	39	"	....	1,600.00	......	0.055	0.06	Maj. G. T. Lydecker, U. S. A.
White	....	5,511.00	13	11	10	9	43	....	....	264.00	......	0.048	......	A. Livermore.

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[1] I am informed that in recent years the James river has fallen far below this figure.

TABLE OF MONTHLY FLOW IN DRY YEARS.

RIVERS.	Drainage area, square miles.	FLOW IN INCHES ON WATERSHED. Driest month.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.	Total for the year.	RATIO OF MONTHLY TO MEAN FLOW. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Eighth.	Ninth.	Tenth.	Eleventh.	Twelfth.
Croton	339	0.20	0.35	0.53	0.63	0.87	0.94	1.52	1.63	1.80	1.90	2.08	2.27	14.72	0.16	0.29	0.43	0.51	0.71	0.77	1.24	1.33	1.47	1.55	1.70	1.85
Concord	352	0.25	0.32	0.36	0.43	0.54	0.68	0.85	1.07	1.36	1.70	2.15	3.62	13.33	0.22	0.29	0.32	0.39	0.49	0.61	0.76	0.96	1.23	1.53	1.94	3.26
Merrimack	4,136	0.68	0.70	0.77	0.85	1.00	1.13	1.30	1.53	1.98	2.55	3.22	5.42	21.13	0.38	0.40	0.44	0.48	0.57	0.64	0.74	0.87	1.12	1.45	1.83	3.08
Connecticut	10,234	0.65	0.68	0.71	0.74	0.88	0.90	1.28	1.51	1.80	2.02	3.28	4.71	19.16	0.41	0.43	0.45	0.46	0.55	0.56	0.80	0.95	1.13	1.26	2.05	2.95
Schuylkill[1]	1,800	0.27	0.30	0.38	0.40	0.53	0.62	0.68	0.79	0.88	0.98	1.08	1.59	8.50	0.38	0.42	0.54	0.57	0.75	0.88	0.96	1.12	1.24	1.38	1.82	2.24

TABLE OF MONTHLY AVERAGE FLOW FOR A SERIES OF YEARS.

Croton	339	0.56	0.95	1.12	1.21	1.43	1.82	2.30	2.57	2.77	3.02	3.60	4.00	25.35	0.26	0.45	0.53	0.57	0.68	0.86	1.09	1.21	1.31	1.43	1.70	1.90
Concord	352	0.39	0.46	0.51	0.61	0.76	0.96	1.25	1.52	1.92	2.38	3.00	4.86	18.62	0.25	0.30	0.33	0.39	0.49	0.62	0.81	0.98	1.24	1.53	1.93	3.13
Merrimack	4,136	0.77	0.88	1.06	1.26	1.52	1.80	2.12	2.49	3.03	3.73	4.63	6.56	29.85	0.31	0.36	0.43	0.51	0.61	0.72	0.85	1.00	1.22	1.50	1.86	2.63
Connecticut	10,234	0.75	0.85	0.91	1.10	1.34	1.58	2.00	2.36	2.81	3.27	4.52	6.26	27.75	0.33	0.37	0.39	0.47	0.58	0.68	0.87	1.02	1.21	1.41	1.96	2.71

TABLE OF MONTHLY FLOW IN DRY YEARS OF STREAMS OF SMALL DRAINAGE AREA

Cochituate	19.00	0.08	0.41	0.46	0.47	0.70	0.88	0.97	1.03	1.11	1.31	1.47	2.26	11.15	0.09	0.44	0.50	0.51	0.75	0.95	1.03	1.11	1.20	1.41	1.58	2.43
Croton, Western Branch	20.37	0.10	0.17	0.46	0.53	0.67	0.84	0.98	1.02	2.31	3.37	3.41	5.40	19.26	0.06	0.10	0.28	0.33	0.42	0.52	0.61	0.64	1.44	2.10	2.13	3.37
Sudbury	76.30	0.11	0.16	0.25	0.39	0.57	0.79	1.06	1.40	1.79	2.21	2.77	5.09	16.59	0.08	0.11	0.18	0.28	0.41	0.57	0.77	1.01	1.29	1.60	2.01	3.69
Passaic headwaters	50:100	0.11	0.15	0.21	0.27	0.49	0.67	0.90	1.22	1.77	1.87	2.13	3.65	13.44	0.10	0.13	0.19	0.24	0.44	0.60	0.80	1.09	1.58	1.67	1.90	3.26

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[1] Charles G. Darrach, in *Engineering News*, April 3, 1880, p. 122.

b. THE MINIMUM LOW-SEASON FLOW is the smallest average amount flowing during a period of from six to three weeks, *generally* in summer, when the stream is at its lowest. In most years the average flow during the season of least flow exceeds this amount. It may therefore be depended upon at all times, except for intervals of a day or two, perhaps several days at a time, during which the flow approaches its absolute minimum, and may be rendered available at all times by a small amount of storage. In ordinary years there will generally be an excess all the time.

This minimum low-season flow can probably be best estimated by comparison with results of observation, some of which are given in the table on page 55. But in most cases I have estimated it as follows:

1. Seven-tenths of the mean annual rainfall may, in general, be considered the minimum rainfall.

2. Forty per cent. of this may, on the average, for tolerably large drainage basins, be considered to be discharged by the streams, subject to variation, however, according to local and climatic conditions; but in no case should the amount determined in this way as the total amount discharged in the year of the minimum low-season flow exceed say 10 to 13 inches.

3. The distribution of this flow through the year may be estimated from the results of the table on page 57, bearing in mind, however, in estimating the coefficient which expresses the proportion of the mean monthly rainfall which is discharged in the driest month, the various remarks concerning the district considered, on pages 53 and 54.

c. THE LOW-SEASON FLOW IN DRY YEARS (BUT NOT THE DRIEST) I have sometimes estimated by assuming the run-off somewhat larger than for the minimum low-season flow, and taking a certain proportion of this as the amount flowing in the one or two months when the stream is lowest, according to the table on page 57, modified according to circumstances. In many cases, however, I have simply increased the estimate given for the minimum low-season flow by an arbitrary percentage. From the above remarks it will be clear that without storage this flow may generally be depended upon except in the low seasons of very dry years when the supply may be deficient for several weeks at a time. *In ordinary years at least one-quarter more may generally be depended upon at all times* than the figures under this head in the tabular statements of power concerning the several streams described in this report indicate.

The month of least flow (the driest month) varies considerably from year to year, falling sometimes in the summer and sometimes in the winter, and the months do not succeed each other in the order of dryness. As a rule, however, the driest months fall in summer, although sometimes the difference is not very pronounced. (See a paper by Mr. Clemens Herschel, "The Gauging of Streams." *Transac. Am. Soc. Civ. Engrs.*, vol. vii, 1878, p. 236.)

In describing the separate waterpowers I have therefore given three estimates. For convenience of reference I will recapitulate them here, noting briefly their exact meaning:

1. THE ABSOLUTE MINIMUM.—This can be depended upon *always*, and with no storage at all. There will be large waste all the time, except for a few days at a time in intervals of several years.

2. THE MINIMUM LOW-SEASON FLOW.—This, with no storage, can be depended upon at all times, except for a short time in some dry seasons. With small storage it can be depended upon all the time.

3. THE LOW-SEASON FLOW IN ORDINARY DRY YEARS (NOT ORDINARY YEARS).—This, without storage, can be depended upon generally, except in the low season of dry years, when the supply will be deficient for, perhaps, several weeks; in very dry years, when the supply will be deficient for a longer time, and in ordinary years, when the supply may be deficient for a few days at a time. It can be rendered permanently available by storage. *The low-season flow of ordinary years* can be depended upon less than the *minimum* described in paragraphs 1 and 2 above; but generally it can be depended upon for nine or ten months of every year.

IN ORDINARY YEARS, during the "low season," a quantity probably at least one-quarter greater than during the "low-season flow in ordinary dry years" may be secured.

Attention is again called to the fact that all the estimates in the following pages must be considered only rough approximations. It is impossible with the data at hand to give anything better.

Especial emphasis is also directed to the fact, just mentioned, that during ordinary years the amount of power available at the different sites during the low season will be much greater than given in the tables, probably at least one-quarter greater.

EFFECT AND FEASIBILITY OF STORAGE RESERVOIRS.

The above estimates are, of course, for the natural flow of streams unaffected by storage reservoirs. By building such reservoirs, a larger quantity of water might be used in a year (by drawing on a wet season to cover the deficiency of a dry one), and it may be used more uniformly throughout the entire year than would otherwise be the case. If suitable reservoirs could be built, it would be possible (allowing, of course, for evaporation) to collect and draw the total quantity of

TIDAL WATERPOWER.

There is no tidal power either used or available in the district considered, partly because there are no facilities for storing water, and partly because, as is evident from the topography of the country, there are no facilities for the location of dams and buildings on a low and swampy coast.

TOTAL AVAILABLE POWER.

It is customary to attempt to estimate the total available power of a district by assuming the average elevation and the quantity of water discharged. Such estimates have little value, because a large proportion of the power so estimated is, in fact, unavailable, on account of topographical features. In regard to the region under consideration, however, it is to be noticed that as the elevation of the Atlantic plain, at the foot of the mountains, is much greater than in the states farther north, varying from 1200 feet in North Carolina, at the sources of the Catawba, to 500[1] feet in Virginia and 100 to 300 feet in Pennsylvania,[1] the total theoretical power in the region we are considering will be very large in proportion to its area, especially if we exclude the eastern division from consideration.

Having presented the general features of the district under consideration, and having briefly pointed out the general principles relating to the amount of power available, and explained the method used in calculating it, it is now only necessary to show how, in the application of those principles, the general characteristics of the region show their effects and are to be taken into account.

GENERAL SUMMARY.

INFLUENCE OF WINDS AND EVAPORATION.

1. It follows from the position of the region that the warm and moist S.W. winds from the Gulf of Mexico traverse its whole extent. Hence the rainfall is greatest (62 inches) in Alabama and southern Georgia, while the evaporation is comparatively small, because the air is moist, and the rainfall diminishes to 44 inches and less in North Carolina and Virginia, while the air becomes drier and the evaporation greater. Above North Carolina the greater part of the rain comes from the Atlantic, while south of Virginia most of it comes from the Gulf. This fact—that the evaporation increases toward the north—has an important bearing on the flow of the streams, which will be referred to further on.

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[1] Guyot.

INFLUENCE OF TOPOGRAPHIC FEATURES.

2. From the topography it follows that all the waterpower of importance is in the middle division. In the eastern division the streams are too sluggish, and in the western they are too small and inconstant. Although the middle division is very favorably located for waterpower, it is unfortunate that in the eastern division, just where the streams are the largest, the conditions are not favorable. The middle division is, topographically, very favorable for power. The fall of the streams is great, but as a whole tolerably uniform, and their volume moderately large. They cross the ledges of rock at large angles, forming many rapids, rifts, or falls in all parts of this region. These ledges, being composed of hard, durable, and impervious rocks, generally granite or similar rocks, insure the permanence of the powers, and afford everywhere good sites for dams. The shape of the river valleys is such as to render the utilization of the power in most cases easy, there being only a very few instances of anything approaching the cañon structure. The facilities for storing water are, on the whole, good, though the shape of the valleys does not seem to be *particularly* favorable; for in the mountains the fall is too great and the valleys too narrow to afford *large* reservoir room, while lower down the rivers are bordered by fertile bottom-lands, which it might be inadvisable to overflow, and besides, as the streams are tolerably large, it would be difficult to store sufficient water to increase the power much. In the matter of storage this region is notably less favorable than such states as Maine and Pennsylvania. The absence of lakes, also, operates unfavorably on the volume and constancy of the streams, especially in the upper parts, and this is counteracted by the action of the forests perhaps to a less extent than might be supposed. (See below.)

The country in the middle division being moderately hilly, the rainfall is neither precipitated suddenly into the river channels, rendering them subject to sudden freshets, nor is it discharged too gradually, so as to render the evaporation abnormally large. On the contrary, the depth and perviousness of the soil, the fact that it is everywhere underlaid with hard and impervious rock, and that the rivers have cut their channels down to this rock-bed, contribute to the volume and constancy of the streams, and diminish the loss by evaporation and by subterranean flowage. This depth of soil, serving to store the waters, is especially beneficial in view of the variability of the rainfall, in which respect some parts of this region stand at a disadvantage, which is thus, to some extent, compensated for. In Maine, for instance, the soil is very shallow compared with that in North Carolina, but the rainfall is very equally distributed throughout the year. (See page 52 for further remarks on this subject.)

INFLUENCE OF FORESTS.

3. The influence of the forests in the western division is favorable, yet not to such an extent as might be supposed, according to what has been said regarding the influence of woods in winter and in summer. In fact, there is reason to believe that at least in the northern parts of the region considered less water percolates into the ground in winter, to be stored and given out by springs, than in open ground. From the experiments which have been referred to, the conclusion has been drawn for Germany that the cutting down of forests has the effect in winter of increasing the discharge of springs and causing a higher average stage of the water in the streams than existed before.[1] In hot regions, and in summer, the cutting down of woods has the opposite effect, but it does not seem improbable that, for the district considered, the effect would be to a certain extent as stated, especially if (as is the case in the western part of the district in many cases) the rainfall is greater in winter than in summer. For this reason it is easy to overestimate the effect of the forests as regulators of flow. Their effect is certainly very much smaller than in regions where the rainfall is greater in summer than in winter, in which case their effect is very beneficial and only exceeded by that of lakes or artificial reservoirs and surface materials. The fact that the mountains in this district are covered with soil is one of great importance, and on this account the flow of the streams will be much more constant than it would otherwise be.

INFLUENCE OF TEMPERATURE.

4. I have already alluded to the winds and the position of this region as affecting its waterpower. As regards temperature, it is, of course, higher in this region than in New England. In summer the difference is some 12°; in winter, over 20°; and for the year, in the middle division, 12° to 15°. The average temperature in winter is far above the freezing point; hence the streams rarely freeze over. Trouble with ice is almost unknown, and, in this respect, this region has a great advantage over the more northern states, which is, however, partially offset by the fact that the evaporation is greater.

Mr. Wells, in his report on the waterpower of Maine, dwells upon the fact, which he says is founded on the testimony of persons who have had the largest and most varied experience in manufacturing in Maine and other states, that operatives can accomplish much more in winter than in summer, and more in cold than in warm states. I quote Mr. Wells' remarks on this point:

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[1] Ebermayer: *Die physikalischen Einwirkungen des Waldes auf Luft* **und Boden, und seine** *klimatologische und hygienische Bedeutung.* Berlin, 1873, p. 223.

"It is well known that at the large majority of manufacturing labors the burden of the day's work is felt by the operative to be much heavier in summer than in winter. The cold of the latter season can be so guarded against and mollified that throughout the whole establishment precisely, or very nearly, that temperature can be secured which is most contributive to vigorous exertion. But the heat of summer, pervading and penetrating everything, and brought in at every open window with the necessary supplies of fresh air, cannot be shut out. It cannot be qualified. It oppresses the worker with a languor rarely experienced in out-of-door avocations, and renders it impossible for him to do so much or do so well as he can easily do in cool weather. Accordingly, the evidence is that in Maine, where the summer temperature is low, where it rises above the point of comfort for but a few days for the whole season, operatives, circumstanced equally in every other respect, accomplish more than in the interior and more southern states by the truly remarkable fraction of 10 per cent."

It must, however, be borne in mind that although in warmer climates the operatives are unable to accomplish so much, yet, on the other hand, the expense for heating the factory buildings is greatly reduced, and that, further, as the operatives can live more cheaply on account of not needing so much artificial heating in their houses, their wages may be much less in proportion. In fact, it is stated that the wages paid to operatives in cotton factories in the Southern states is from 30 to 50 per cent. less than in the New England states.[1] The table of maximum observed temperatures shows that the maximum observed temperature in Maine is about the same as in Georgia. The following table of the mean temperatures of the hottest and coldest months of the year will enable a comparison to be made between the New England states and the Southern states, and will show that the difference is not so great as is generally supposed.

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[1] According to the census of 1890, the average wages paid to operatives in cotton factories in various states was as follows, in dollars, per annum: Maine, 304; New Hampshire, 321; Vermont, 281; Massachusetts, 334; Rhode Island, 314; Connecticut, 319; Pennsylvania, 348; Maryland, 250; Virginia, 188; North Carolina, 172; South Carolina, 187; Georgia, 207. The wages will depend somewhat on the quality of goods manufactured, but the average is evidently much less in the south.

TABLE OF MEAN TEMPERATURES OF HOTTEST AND COLDEST MONTHS IN VARIOUS PLACES.

PLACE.	Number of years of observation.	Mean temperature of hottest month. July.	Mean temperature of coldest month. January.
Bath, Me.	11	68.7	23.2
Castine, Me.	40	64.8	21.4
Brunswick, Me.	52	67.4	20.1
Newport, R. I.	63	70.1	29.9
Providence, R. I.	34	70.9	25.8
New Haven, Conn.	23	71.8	27.5
Hartford, Conn.	24	71.9	27.6
Manchester, N. H.	22	72.3	23.2
New York, N. Y.	25	73.5	30.5
Newark, N. J.	54	74.1	29.2
Philadelphia, Pa.	25	75.7	32.0
Harrisburg, Pa.	8	72.9	30.3
Baltimore, Md.	25	77.2	34.0
Washington, D. C.	25	76.8	33.2
Norfolk, Va.	26	78.7	40.6
Southport, N. C.	18	80.0	46.3
Chapel Hill, N. C.	36	78.6	39.9
Asheville, N. C.	18	72.4	38.9
Aiken, S. C.	35 25	79.9	45.5
Charleston, S. C.	25	81.8	50.0
Columbia, S. C.	18	81.0	46.3
Fort Moultrie, S. C.	34	81.7	50.2
Athens, Ga.	20	78.5	42.7
Atlanta, Ga.	18	78.0	42.5
Augusta, Ga,	25	81.1	46.6

Most of the stations in the Southern states are in the eastern division, where the weather is much warmer than in the middle and western divisions, where the waterpower is. The table shows that at Athens and Atlanta, Georgia, which are the best types of the middle section, the mean temperature of the warmest month is not much different from that in the Middle states, although Maine, it is true, has a lower temperature by some 10°. It seems to me, however, that this effect of temperature has been overestimated, and that, so far as it alone is concerned, the advantages in the Southern Atlantic states more than counterbalance the disadvantages.

INFLUENCE OF RAINFALL.

5. As regards the rainfall, its distribution throughout the year on the watershed of each river is to be carefully considered. Variability in this distribution may not be a disadvantage, but on the contrary, if the summer fall is greater than the winter fall, the flow of the streams will be more regular, other things being equal. In determining the ratios to be used in estimating flow I have been influenced by this consideration, and if of two streams, similar in other respects, one has more rain in summer than in winter, and the other more in winter than in summer, I have taken the minimum flow of the former considerably greater than that of the latter. Differences in the evaporation in different parts of the district also come into consideration. If the other

climatic conditions remained the same, the effect of variability in the rainfall would be seen in a corresponding variation in the flow of the streams, and in those seasons when most rain fell the flow of the streams would be greater. Yet in the New England states, as well as in the Southern states, the streams are lowest in summer, even when more rain falls in that season, showing that the evaporation in that season is more than sufficient to make up for the greater rainfall. It is true that in the North there is a winter drought, caused by the snow lying so long on the ground, so that little of the precipitation reaches the streams; yet, although in some cases the driest month, or the month when the streams are lowest, falls in the winter, in general the summer drought is greater than the winter drought. On account of the increased evaporation, the southern streams will, in all probability, discharge a smaller proportion of the rainfall on their drainage areas than those in New England. Finally, the effect of soil and lakes must not be overlooked in comparing this region with New England, and in estimating the flow of the streams.

The foregoing remarks have been made because it is necessary to present the principles which have guided me in making the estimates in this report. The conditions determining the flow are, however, so various, that they cannot all be given due weight, even if they were all accurately known; so that the only safe guide in practical questions regarding flow is a series of gaugings extending over a number of years. But as there is not a single such series for the district considered it is necessary to resort entirely to estimate. Every engineer can form his own conclusions from the data at hand, and many may not be disposed to approve of the figures given.

CHAPTER IV.

GEOLOGIC DISTRIBUTION OF WATERPOWER.[1]

GEOLOGIC CONDITIONS AFFECTING WATERPOWER DEVELOPMENT.

Even the most casual observer must be aware of the fact that the falls and shoals in rivers, upon which we usually depend for the development of waterpowers, have a more or less intimate connection with the hardness, durability and arrangement of the rock masses that are crossed by the channels of these streams; and in calling attention to this phase of the subject it is thought best to explain briefly the nature of this connection in certain of the types more commonly met with.

IN AREAS OF HORIZONTAL BEDDED ROCK.

One of the most common and simple examples of this connection is illustrated by the accompanying diagram (fig. 7), in which the layers of rock which underlie the stream are practically horizontal, and are alternately massive and composed of durable material, such as limestone and sandstone (*a*), and thinly bedded shales (*b*) which are softer and more easily eroded. In the course of time the sand, gravel and bowlders carried down by the stream wear through the overlying hard rock at some point and then more rapidly cut away the underlying layers of soft material, the result being, first, a succession of rapids or shoals, and later, a vertical fall (as at 1) at least as high as the thickness of the shale material. In a similar way another fall may be produced a short distance further down the stream (as at 2), the amount

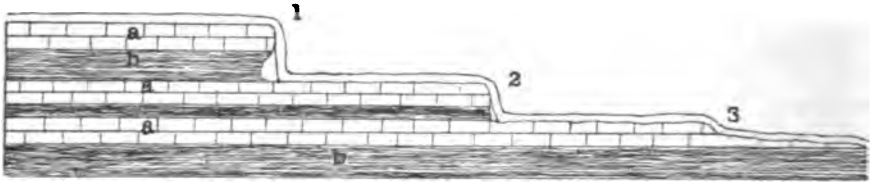

Fig. 7.—Hard and soft horizontal strata, favoring the development of waterfalls and rapids in river channels. *a*=Limestone. *b*=Shale.

[1] By J. A. Holmes.

of the fall there being less in proportion as the underlying layer of soft shale is thinner. Still further below (at 3) rapids or cascades are produced, owing to the irregularities in the character of the layers of harder rock and the consequent irregular wearing. The exact conditions here illustrated probably do not occur in North Carolina, but may be found approximated at Niagara Falls and many other places in the United States.

IN AREAS OF BEDDED SANDS AND CLAYS.

In some portions of the coastal plain region, however, where the streams are cutting their way down across the horizontal and soft strata such as alternate beds of clay and sand, we have conditions somewhat similar to those described above except that in these cases the strata, instead of being alternate layers of hard and soft rocks, are of altogether unconsolidated materials which have not yet turned to stone.

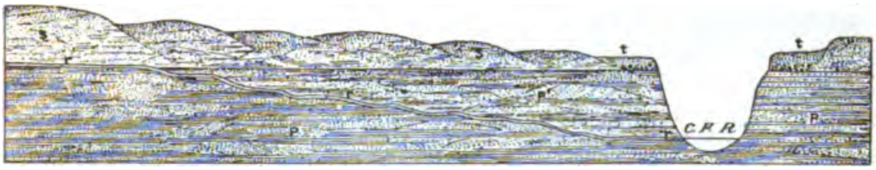

FIG. 8.—Interbedded sands and clays favoring the development of rapids in river channels.

P and *P'*=Finely laminated and in places cross-bedded, black laminated clay below, and bedded but cross-laminated clayey arkose above, the strata of both clay and arkose being separated by layers of sand varying in thickness from a small part of an inch to several feet. The strata marked *P'* above *rr* represent the same strata as *P* below the *rr*. *s*=Sand hills back from the stream border. *t*=River terraces of recent loams, gravel at their base. *rr*=Surface of the stream showing that as it washes away the laminated arkose and clay irregular rapids are produced in the stream, owing to the more rapid removal of the interbedded sand.

Such a condition of things may be illustrated by fig. 8, which represents somewhat the conditions existing on Rockfish creek in Cumberland county, described in a subsequent chapter (p. 138).

In the lower portion of its course the waters of Rockfish creek have cut their way down through the overlying sands and loams and are now cutting through the lower interbedded sands, clays and arkose, (p. 138) and the still lower more finely laminated sands and greenish-black clays. Near the mouth of Rockfish these materials in its bed have been worn away to the level of the Cape Fear river which it joins. Further back from the Cape Fear the cutting down through alternate layers of loose sand and tough clay has resulted in producing a rapid but irregular current with occasional small shoals, at several of which waterpowers have been developed by the construction of dams and factories erected.

IN AREAS OF TILTED BEDDED ROCK.

Figure 9 illustrates another condition of common occurrence. In this case the rocks resemble in character those in many portions of the country, especially in the southern Appalachian region, including portions of western North Carolina described above (p. 25), but the strata extending across the bed of the stream are inclined at high angles, often standing on edge. The upturned edges of these layers of rock vary greatly in character, some of them being (*a*) hard and durable and others (*b*) soft and easily worn away by the sand, gravel and bowlders swept along in the stream. When the water flows rapidly down such a stream we have resulting a river channel which is as a rule an extremely rough one, with here and there projecting ledges of hard rock extending across the stream with as much regularity as though they were laid in masonry; while alternating with these are the hollows and depressions worn into the surface of the softer rock. Where a large mass of the softer rock comes just below a large mass of hard materials (as at 1 in fig. 9) the conditions are favorable for the development of a fall or cascade of considerable height; but where there is less of the hard stone (as at 2, fig. 9) the extent of the cascade or rapid will be considerably diminished; and where there are a succession of alternating hard and soft layers (as at 3) the conditions are favorable for the development of a succession of rapids or cascades. If on the other hand the strata crossed by the stream are fairly uniform in character there will be generally a corresponding uniformity in the current of water.

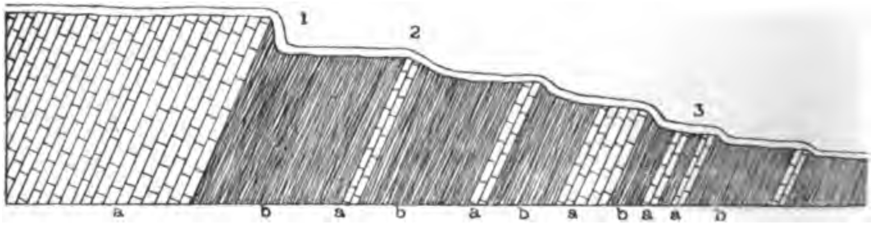

FIG. 9.—Hard and softer inclined strata, favoring the development of cascades and shoals in river channels. *a*=Limestone. *b*=Shale.

IN AREAS OF SLATES AND CRYSTALLINE SCHISTS.

One of the most common types of geologic structure affecting waterpower development in North Carolina and other South Atlantic states is that to be found in the great belts of slates and crystalline schists lying in the eastern part of the Piedmont plateau region. (See map, p. 78). Here, as in the structural type shown in fig. 9 above, layers or sheets of rocks are nearly vertical, and are composed of material varying in hardness and durability; but throughout much of this belt, and especially along its western border, the variations are less well defined and on a smaller scale, the thin, hard layers being so numerous and so generally distributed that in the streams like the Haw and Deep rivers, which cross the larger portions of these belts nearly at a right angle, there is almost a continuous series of small rapids or shoals with an aggregate fall of from 5 to 20 feet to the mile.

THE "NARROWS" SECTION ON THE YADKIN.

Where the Yadkin river crosses the larger of these belts of slates and schists there is a greater concentration of the hard and soft material, and consequently a greater concentration of fall in the river at certain points, than is described above as occurring on Haw and Deep rivers; yet on the whole this Yadkin river section, illustrated with approximate accuracy in fig. 10, may be considered as fairly typical for sections of country where these belts of rock exist. The space between 1 and 2 in the diagram represents the "narrows" section, a distance of nearly 5 miles. The rock is eruptive in character, though an obscurely bedded conglomerate at the upper (N.W.) side. It is all hard, but not uniformly so, being harder and more obdurate at certain places, arranged at intervals, producing the narrows rapids at the upper end (just below 1) and the "little falls" and "big falls" near the lower end (just above 2). The total fall from 1 to 2 is nearly 100 feet.

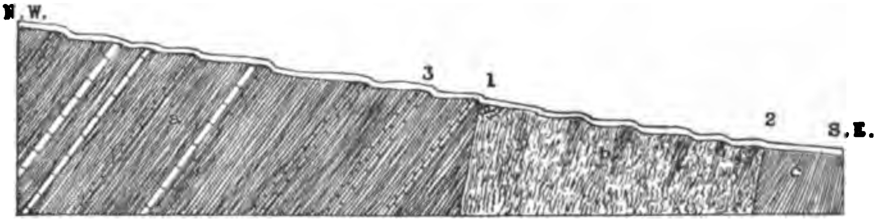

FIG. 10.—Conditions favoring the development of cascades and rapids in river channels crossing belts of inclined slates and crystalline schists.

a=Argillaceous slates dipping Northwest, with harder and more durable layers at intervals (as at 3). *b*=Crystalline schists, mainly of volcanic origin, obscurely schistose, more massive and obdurate in places, as where the shading is heavier. *c*=Finely laminated and uniform argillaceous slate.

Below the narrows (between 2 and S.E. in fig. 10) the rock is mainly an argillaceous slate of fairly uniform character and easily eroded by water action; and the existence of this softer material beside the belt of hard, obdurate rock which itself is not uniform, but has harder and softer belts, affords just the conditions favorable for the development of rapids and cascades in the stream that crosses both belts. As might be expected, these harder rocks (*b* in fig. 10) cross the country in a high, irregular ridge, while the surface of the region to the southeast, occupied by the slaty and sandstone rocks, is less hilly and less elevated. The Yadkin crosses the harder ridge as a rushing torrent in a deep, narrow gorge—the "Narrows"—but as soon as it reaches the softer slaty rock (at 2 in fig. 10) the current slackens, the stream widens and flows on for several miles as a smooth and relatively sluggish current.

For several miles up-stream from the Narrows the rocks are mainly clay slates having a southwest-northeast course, and dipping steeply toward the northwest; and so the sheets or beds of rock stand on edge and lean down-stream (S.E.). These rock beds are for the most part fairly soft and more easily washed away than other more massive and more durable layers which occur at irregular intervals, and consequently below these more massive sheets of rock are the shoals and rapids as indicated in figs. 9 and 10 above and as described further on (pp. 178-187).

IN GRANITIC AND GNEISSIC AREAS.

In granitic and gneissic rock, the materials not being arranged in definite strata or layers, the exact conditions which cause the production of cascades and rapids in streams are less apparent than in the slaty and schistose rocks just described. The accompanying sketch (fig. 11) illustrates a few of the conditions favorable to the development of waterpowers in a region where these rocks prevail, as in portions of central and western North Carolina.

1. One often finds in such regions breaks, such as faults or joints in the rock, the material on one side of the break being somewhat crushed or sheared and hence easily removed. Of course the streams of water in crossing the section of country where these breaks or faults occur, and especially where the crushed or sheared side of the break is the lower side on a sloping surface, remove this lower side more rapidly than the upper and thus form a cascade from the higher to the lower level as seen at 1 in fig. 11. It is in that way that some of the beautiful falls of the southern Appalachian mountain region have been produced. Other cascades and shoals are developed under the following conditions:

2. In portions of the granitic area there are lines of structural weakness where, under great strain or pressure, the materials of which the

rock is composed give way and are flattened out by a process known as shearing, so as to give there a rather gneissic or schistose structure, as at 2 in fig. 11. The rock in this condition is often more rapidly attacked by the weathering and eroding forces of the atmosphere, and, consequently, as the streams cross the surface of the country where such conditions exist, they carve out their channels more rapidly, thus producing shoals or rapids, and, in extreme cases, cascades or falls.

3. Conditions somewhat similar to the above and favorable to the formation of shoals and rapids in streams are sometimes found along the line of contact between areas of granites and gneisses, as at 3 in fig. 11; and again in gneissic areas in places the rocks are harder and more obdurate, as indicated by heavier shading at 4 in fig. 11; and in the beds of streams crossing such areas the rocks wear away irregularly, the harder portions standing up as projections while the intervening softer materials are hollowed out. In this way we have produced a succession of shoals, a few hundred yards or several miles apart; and between these are to be found the quiet reaches of the streams where the current moves along more smoothly and quietly.

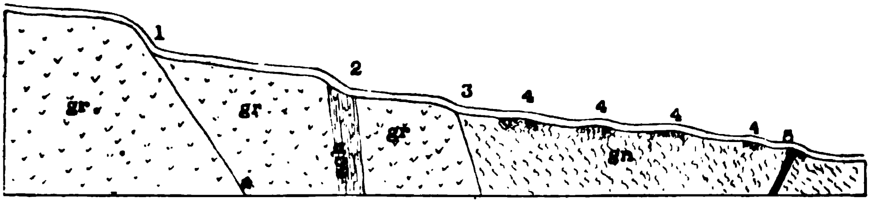

FIG. 11.—Conditions favoring the development of cascades and rapids in river channels crossing areas of granitic and gneissic rock.

gr=Granite. 1=Fault or break in the rock, the right side having moved down or the left side moved up. 2=A schistose zone in the granite resulting from the shearing or movement of the rock along a line of weakness. *gn*=Gneiss, in which there are alternately harder and softer portions, the harder and more obdurate places being more heavily shaded (as at 4). 5=Dike of diabase or other material harder and more obdurate than the gneiss, and hence producing a cascade or rapid in the stream channel.

4. Another structural feature in granitic and gneissic areas, and also in slaty and sandstone areas, which occasionally results in the production of the shoals and rapids, is the occurrence of dikes, where cracks in the earth's crust have been subsequently filled with various materials in a plastic and usually a molten condition and which materials have subsequently hardened. If the material of the dike is softer than that of the granite or gneissic rock on one or both sides of it, then there will be a drop in the course of the stream from the adjoining rock of the wall down on to the softer dike surface, as is shown at 2 in fig. 11. If

on the other hand the material constituting the dike is harder and more durable than the materials on each side of it, the country rock on the lower side of the dike, on account of its being softer and less durable than that composing the dike itself, will wear away more rapidly than the material of the dike, and consequently the water will drop from the dike surface on the country rock below it, as indicated at 5 in fig. 11 above. The occurrence of the belt of eruptive rocks between the two belts of slate, as shown in fig. 10 (p. 71), may be considered as analogous to this last-mentioned case. On Deep river near Gulf (p. 162) and on New Hope creek, a tributary of Haw river, are to be found illustrations of the development of waterpower being favored by the occurrence of diabase dikes in the Jura-trias sandstone crossing the channel of the stream.

AT GEOLOGIC CONTACTS.—THE FALL LINE.

The conditions described above apply more specifically to variations in the character of the rock within the limits of individual geologic formations, but the descriptions are applicable also to conditions existing where the stream crosses from one formation to another, the rocks of which are softer and less obdurate, and hence more easily washed away. Such a case as the last mentioned is to be found well developed at the *fall line* along the border between the Piedmont plateau and coastal plain regions.

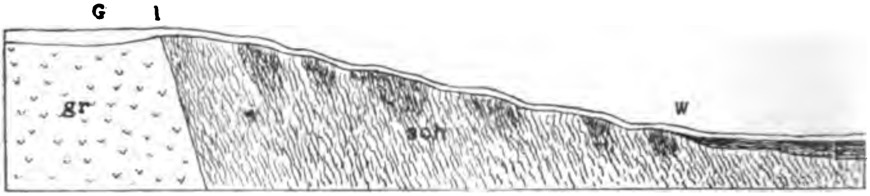

FIG. 12.—Conditions favoring the development of cascades and rapids in stream beds crossing geologic contacts.

gr=Granite and gneiss. *sch*=Crystalline schists, in which the harder places (shaded more heavily) wear away less rapidly than the intervening softer places. The result is a series of cascades and rapids in the stream. *P*=Coastal plain deposits—gravel, sand and loam.

THE WELDON SECTION ON THE ROANOKE.

Figure 12 may be considered as illustrating fairly well a generalized section across the fall line where crossed by the Roanoke river at Weldon. The crystalline schists exposed along the river bed between Gaston and Weldon (G and W of fig. 12) are much harder and more obdurate than the unconsolidated coastal plain deposits below, and even harder than the granitic and gneissic rocks above it; and hence the latter rocks have been eroded to greater depths, and at the line of junction between the two (1 in fig. 12) the schists form a sort of barrier or natural dam, for many miles above which the river is deep and the current sluggish. But from this point down to Weldon the schists vary in hardness, and are intersected by joints, seams, fissures and probably several faults; this succession of variations giving rise to a succession of rapids and shoals, with an aggregate fall of 85 feet in a distance of 9 miles. For this distance the river flows through a deep and open gorge flanked by hills which, near Gaston and a short distance westward, are capped with unconsolidated gravels, presumably of Potomac age, and bordered by terraces of more recent age, probably post-tertiary (Columbia). In the neighborhood of Weldon and eastward the rocky hills give places to the terraces and plains of the coastal region, composed of gravels, sand, loams and clays, varying in age from Potomac at the bottom to Columbia at the top.

During recent geologic times the condition of this region has been unstable. During certain periods, as at the present time, the surface of the country has been lifted to a considerable elevation above sea-level and the river has gone on carving deeper its rocky channel; while during intervening periods the surface was lowered until the sea advanced to and even above Weldon, and the river gorge would then be filled with gravels and sands and loams brought down from the Piedmont plateau, distributed and deposited in the great tidal estuary, to be wholly or partially washed out of the channel at each successive elevation. The tongue of coastal plain deposit, shown as P in fig. 12, is an unremoved remnant of probably recent filling, the bottom of the river at this point being now too near tide level to permit of further removal of this material from the submerged eastward sloping surface of the old crystalline schists. There are also many reasons for believing that another of the results of the unstable condition of this region has been the decided eastward tilting of the irregularly eroded surface of these old crystalline rocks upon which the coastal plain loams and gravels were subsequently deposited.

GEOLOGIC CONDITIONS FAVORING WATERPOWER DEVELOPMENT AT THE FALL LINE.

(1). The eastward tilting of the surface of these older crystalline rocks, and (2) the partial removal of the loose and easily eroded loams and gravels from the channel on the eastern slope of these rocks, have given this resulting descent in the river surface at the fall line, which, in the Roanoke at Weldon, aggregates 85 feet in 9 miles. (3) The variation in the character of the rock, being harder and more obdurate at certain points, and softer, more jointed, more crushed, and hence more easily eroded in the intervening areas, results in concentrating this fall of the stream at certain places; and (4) the existence of terraces along the river banks facilitates the construction of canals which still further concentrate the fall of the water. These are the more important geologic conditions that favor the development of important waterpowers on the Roanoke at the fall line in the Weldon region.

Other striking cases illustrating the conditions favoring waterpower development on streams crossing geological contacts will be found mentioned on pp. 116 and 132 of this report.

GEOLOGIC CONDITIONS AFFECTING THE FLOW OF STREAMS.

The yearly discharge of a stream depends primarily on the amount of rainfall in the region from which the stream draws its supply, but in a measure this volume, and especially the uniformity of flow, are largely influenced by the slope of the surface, the depth and porosity of the soil, and the character of the underlying rock. In connection with this study of the geologic conditions influencing the possibilities of waterpower development, it should be noted that the occurrence of lakes, swamps or marshes and poorly-drained level areas, deep and porous soils, such as the sandy and gravelly soils from 10 to 100 feet deep, which occur in the larger part of the Piedmont plateau and mountain regions of the Carolinas, the great sand hills of the coastal plain region, and the porous sands and gravels of the glaciated regions of the Northern states, all facilitate the uniformity of the flow of the streams in these several regions; and in some regions the jointed, fissured and crushed condition of the underlying rock exerts a favorable influence in the same direction. (See also pp. 138-140; 192.)

DISTRIBUTION OF WATERPOWER IN NORTH CAROLINA.

The two conditions essential to the development of a waterpower of any considerable magnitude are a large and fairly constant stream of water and a suitable amount of fall within a reasonable distance. In the eastern counties of North Carolina we have numerous large streams of water, but, except along the western border of the region, as a rule they have sluggish currents and are lacking in the necessary fall. In the mountain counties the streams are small, but the fall available in many cases is sufficiently great to make possible waterpowers of considerable magnitude. It is in the midland counties, however, that we find the most satisfactory combination of the two essential conditions, viz. volume of water and fall; and hence it is in these counties that we may expect the largest waterpower developments and the greatest and most substantial development of manufacturing enterprises.

In the following chapters of this report will be found descriptions of the several rivers occurring in North Carolina and the more important waterpowers on each, both those already developed and those still unimproved. It is intended in the present chapter to discuss briefly the distribution of these waterpowers in their relation to the geologic features, and the accompanying map (fig. 13, p. 78), together with the illustrations and descriptions found in pages 68 to 76, will prove of service in this connection. The larger map (Plate I, frontispiece) will also be of service in showing the general distribution of waterpower in the state.

WATERPOWER IN THE COASTAL PLAIN REGION.

Along the western border of the coastal plain region there are a number of important waterpowers, like those at Weldon on the Roanoke, Rocky Mount on the Tar, and those on the Cape Fear as far east as Averasboro. These, though they lie within the limits of this region, yet structurally do not belong to it, and can best be considered under the next heading below, in which will be discussed the waterpowers which belong rather to the border zone between the coastal plain and the Piedmont plateau regions, and which can perhaps be best designated as the fall-line zone.

With the exception of the waterpowers just referred to, it may be said of the coastal plain region, as a whole, that its waterpowers are of no great importance. The water supply is ample but the fall is lacking. And yet there exist at many different points in this region conditions which are favorable to the development of waterpowers which, though small, have considerable local value. Until a comparatively recent date, practically all of the grist-mills in this section were operated by small waterpowers, and a considerable number of these gristmills are still in operation. But such waterpowers were confined to the smaller streams, and in many cases the development of power consisted simply in the construction of a dam across the deep, narrow channel of the stream without the existence of a natural shoal, and the amount of fall was simply the height of the dam.

One not uncommon type of waterpower developed in this region is illustrated by fig. 8 (p. 69). In many cases, however, the harder and more obdurate strata which caused the fall in the water to be concentrated at one or more points, instead of being composed of compact and finely laminated beds of clay, as shown in the illustration just referred to, are composed either of more massive beds of clay or of beds of sand, the particles of which are cemented together by clay or iron or both.

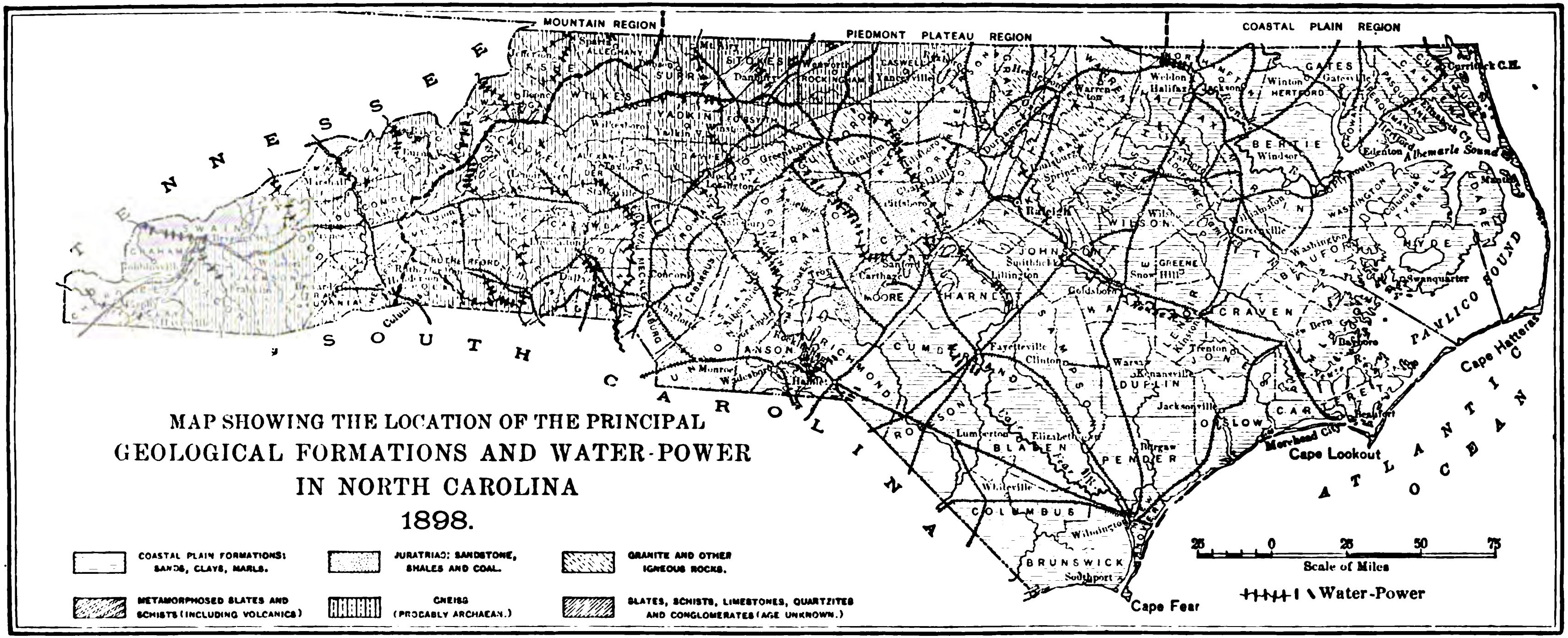
MAP SHOWING THE LOCATION OF THE PRINCIPAL
GEOLOGICAL FORMATIONS AND WATER-POWER
IN NORTH CAROLINA
1898.
COASTAL PLAIN FORMATIONS: SANDS, CLAYS, MARLS.
JURATRIAS: SANDSTONE, SHALES AND COAL.
GRANITE AND OTHER IGNEOUS ROCKS.
METAMORPHOSED SLATES AND SCHISTS (INCLUDING VOLCANICS)
GNEISS (PROBABLY ARCHAEAN.)
SLATES, SCHISTS, LIMESTONES, QUARTZITES AND CONGLOMERATES (AGE UNKNOWN.)
MOUNTAIN REGION
PIEDMONT PLATEAU REGION
COASTAL PLAIN REGION
TENNESSEE
SOUTH CAROLINA
ATLANTIC OCEAN
PAMLICO SOUND
Albemarle Sound
Cape Hatteras
Cape Lookout
Cape Fear
Scale of Miles
25 0 25 50 75
Water-Power

FIG. 13.—MAP SHOWING THE GEOLOGIC DISTRIBUTION OF WATERPOWER IN NORTH CAROLINA.

The most striking feature about the waterpowers developed on the majority of these smaller streams is the slight extent to which the volume of water is affected either by the rains or the dry seasons. The most widely known illustrations of this condition are Rockfish creek in Cumberland county, and Hitchcocks creek in Richmond county, both of which are described somewhat fully further on in this report (pp. 138 and 190), and the explanation there suggested of this phenomenon is undoubtedly the correct one, that the deep, porous sands of the region serve as a sponge in soaking up the rains as they fall, turning loose this water gradually during the dry season through the numerous springs in the region.

In the case of many other of the small powers in this region, as that on Colly creek in Bladen county (described on page 138) and others in the different eastern counties, the uniformity of the flow throughout the year is favored by the further condition that the tributaries of these streams pass through extensive swamp areas which also serve to store the water during wet weather.

WATERPOWER IN THE FALL-LINE ZONE.

Reference has already been made (p. 74) to the existence along what is called the "fall line" of conditions favorable for the development of waterpowers of considerable magnitude on our larger streams. It has also been suggested (p. 21) that since the exact position of this fall line is not clearly defined, and as the conditions favoring waterpower development extend across a considerable belt or zone where this line is crossed by the larger streams, it is better in this connection to consider together these conditions as they exist at and for a few miles on both sides of this boundary line between the coastal plain and the Piedmont plateau regions.

ON THE ROANOKE RIVER.

The conditions favoring waterpower development on the Roanoke river in this zone, which at this point has a width of about 9 miles, extending up the river from Weldon, have been described and illustrated briefly above (p. 74). Waterpower developments now in progress there are described in the next chapter (pp. 94-98).

ON THE TAR RIVER.

On the Tar river there is but one large waterpower, that at Rocky Mount, which may be considered as being at the eastern margin of this zone and some 20 miles eastward of the western border of the coastal plain region. As described on page 115, the Tar rises nearly 100 miles to the northwest of this point and crosses successively several granitic, schistose and slaty belts of rock, but owing to the slight elevation of this upper part of its basin above that of the coastal plain, the long period during which the rocks of this upper basin have been undergoing surface decay, and the long period during which this stream, with no great volume of water, has been slowly carving out its channel, its freedom at the present time from conditions favorable to waterpower is easily understood. At Louisburg there is a fall of several feet owing to a change in the character of the granitic rocks. Thence southeastward, for a distance of more than 15 miles, it crosses the granitic area with the conditions of rock so uniform as to yield no cascades or shoals of importance. It then enters the coastal plain region and continues for another 15 miles in a southeasterly course across the upturned edges of the crystalline schists, from the surface of which, in the channel of the stream, the (younger) loose loams and gravels have been carried away. In this distance there are two small shoals which have been developed for grist-mills, but the rocks are too soft and the channel already eroded too deeply and uniformly to leave at individual points any large amount of fall. The river then turns northeastward, and for a distance of some miles follows the course of these crystalline schists instead of cutting across them. Just at Rocky Mount it turns eastward and crosses a ledge of hard granitic rock, on the eastern slopes of which there is a natural fall of about 15 feet in the course of 100 yards. It is on the top of this granitic ledge that the dam has been built which serves for the full development of this waterpower for operating the Rocky Mount cotton-mill.

ON THE NEUSE RIVER.

On the Neuse river, as on the Tar, there is rather a remarkable absence of conditions favorable to the development of large waterpowers. Of the two powers described in the succeeding pages of this report (pp. 121-124), both lie within the granite area, one to the north and the other to the east of Raleigh, and are due to local changes in the character of the granitic rock. At ordinary low water the slaty rocks are exposed in the river bed at Smithfield some 30 miles southeast of Raleigh, and the river has a slight descent at this point but not sufficient to be favorable for waterpower developments.

ON THE CAPE FEAR RIVER.

The fall-line zone on the Cape Fear river may be said to begin where this river is formed by the junction of the Deep and Haw rivers, and to extend from that point to a short distance below Smileys falls, near

Averasboro. In this distance of about 35 miles there is a succession of shoals beginning just above with Buckhorn falls, 9 miles below the junction of the two rivers, where there is a fall of 20 feet in a distance of one and one-half miles, while the lowest of the prominent shoals, "Smileys falls," 30 miles below the junction, has a fall of 27 feet in a distance of three and one-half miles. The total fall from the junction of the two rivers to just below Smileys falls is about 100 feet. Within 17 miles below Smileys falls, by river, there are at least three different shoals, the last of which is only 8 miles above Fayetteville; but none of them are of any importance, and they need hardly be considered in this connection, for the reason that in this distance the river runs in a nearly southwesterly course, parallel to the fall line. All of the more important of these shoals are described briefly in a succeeding chapter (pp. 132 to 137).

The outlying gravels of the coastal plain deposits are to be found on the hills two miles to the west of the junction of the Haw and Deep rivers, so that all the shoals just mentioned lie within this region, and the sands and loams and gravels characteristic of the border deposits are exposed here and there in the river bluffs, though in the river channel these have been removed and the waters rush along over the upturned and irregularly eroded edges of granites and crystalline schists. Within a few miles above the junction of the Haw and Deep rivers both of these streams pass from the slates of the Piedmont plateau region to and across a narrow strip of Jura-trias sandstone, which latter is made up of materials far more easily eroded than the slates, and as might be expected there are shoals on both streams at this junction. The rivers join within this sandstone area, and for a few miles below the junction the Cape Fear is a sluggish stream.

ON THE YADKIN-PEE DEE RIVER.

On the Yadkin-Pee Dee river a condition of things exists somewhat similar to that on the Cape Fear just mentioned. The course of the Yadkin river as it crosses the slates, for some 15 miles above its junction with the Uharie, has been already briefly described (p. 71); and the numerous shoals on the river throughout its entire length are described in a following chapter (p. 172). Below its junction with the Uharie the river flows for a distance of some 20 miles in a southerly course obliquely across and in places paralleling the upturned edges of the argillaceous slates. In this distance there are only two prominent shoals, but neither of great importance as compared with those at the narrows above. These are Swift Island shoal, 42 to 44½ miles above the state line, which has a fall of 18 feet in 2½ miles; and Gunsmith shoal, 13 miles further up the river, with a fall of 9½ feet in half a mile. Further down, the river flows easterly as a somewhat sluggish stream across a few miles of red sandstone rocks, similar to those crossed by the Cape Fear at the junction of its two tributary streams. It then enters the coastal plain region, near where it is joined by Little river and follows a southerly course to Cheraw, 35 miles below. Throughout this distance there is a succession of shoals due to the fact that the river crosses the upturned and irregularly eroded edges of alternate beds of slaty and granitic rocks. The two most important of these shoals are Bluitts "falls," 12 miles above the state line, with a fall of 9 feet in a distance of 1000 feet, and Grassy Island shoal, 13 to 17½ miles above the state line, with a fall of 36 feet at a distance of 4½ miles.

The river crosses the lower limit of the fall-line zone a little above Cheraw. The shoals in the river at that point and for some distance above are not large, but they are sufficient to mark the passage of the river from its characteristics in the Piedmont plateau region to its typical coastal plain condition, that of a sluggish stream.

WATERPOWER IN THE SLATE BELTS.

The origin and nature of the shoals and rapids favorable for the development of waterpower in slaty and schistose areas have already been briefly described above (p. 70). The general distribution of these slate belts in North Carolina is shown on the accompanying small map (p. 78). The possibility of waterpower development on the Haw, Deep and Yadkin, as they cross the central and most extensive of these slate belts in Alamance, Randolph, Davidson, Stanly and Montgomery counties, is greater than on any other portion of these rivers.

ON THE HAW AND DEEP RIVERS.

Both the Haw and Deep rivers rise in the granitic and gneissic area, the former to the northwest and the latter to the southwest of Greensboro, and are sufficiently large in volume to be available for small powers by the time they reach the western border of the slate belt. Throughout their course of about 50 miles across it each river is a succession of shoals or rapids, many of which have already been developed, while a number of others are capable of being developed on a considerable scale. The slates and schists of this region have a general northeasterly course, and, as a rule, dip steeply toward the northwest, so that these streams with a southeasterly course have cut their beds directly across the upturned edges of the slates, which vary in hardness and obduracy from point to point, the harder sheets projecting upward as ledges, and the intervening softer sheets being washed out as depressions, which thus give rise to the shoals and rapids, elsewhere described in this report (pp. 146 and 159).

Deep river in the neighborhood of Carbonton leaves the slates and enters the red sandstone basin, and for a considerable distance flows in this latter material as a deep, sluggish stream. At one or two places, however, extensive trap dikes lie across the bed of the stream and have resulted in the development of small waterpowers. About one mile above Lockville the river leaves the sandstones and crosses a narrow neck of slates and again passing from this slate to the sandstone to the eastward a considerable fall is produced, and an excellent power has been developed at Lockville (p. 159).

ON THE YADKIN RIVER.

The Yadkin river strikes the slate belt some 12 or 15 miles below the Southern railroad crossing near Salisbury, and for a distance of 20 miles below this point the geologic conditions in this slate have resulted in a succession of shoals and rapids which promise to be of great value in connection with the development of manufacturing enterprises. These conditions have been described briefly above (p. 71) and the extent and character of the shoals are described at considerable length further on in this report (pp. 176 to 184). From the mouth of the Uharie to the mouth of Rocky river, a distance of some 15 miles, the river follows a general southerly course, crossing the slates so obliquely, and in the region where the character of the slates is so nearly uniform, that but few shoals are produced and these of no great magnitude as compared with those above the Uharie.

On another small stream, the south fork of the Catawba, which crosses the slate areas in Lincoln and Gaston counties, the influence of the slaty structure in the development of waterpowers is shown in a marked degree. On this small stream from Lincolnton to where it joins the Catawba river at the state line, a distance of something more than 25 miles, there is a succession of shoals not unlike those existing on the Haw and Deep rivers as described above. On not less than a half-dozen of these shoals cotton-mills have been built and are being operated.

WATERPOWER IN THE GRANITIC AND GNEISSIC AREAS.

The larger granitic and gneissic areas occupy the region from the western border of the slate belt just mentioned westward to the foot of the Blue Ridge, the typical Piedmont plateau section of the state.

ON THE DAN, MAYO AND SMITH RIVERS.

In the northern portion of this area we find a condition of things extending from the southern boundary of Stokes county to the northern boundary of Rockingham county, which illustrates in a rather striking way the influence of geologic structure in the production of waterpower. Within the limits mentioned the Dan river flows through a narrow Jura-triassic area composed of sandstones and shales, and owing to the fact that this material is much more easily eroded, the surface of the country occupied by it has been reduced to a level from one to two hundred feet below the contiguous areas of gneissic rock. The main tributary of the Dan river rises in Patrick county, Virginia, and flows in a general southeasterly course across the elevated and hilly surface of Stokes county, and across the strike of the gneissic rock which enters most largely into the geologic formation of the region. Near the southeast corner of Stokes county it enters the sandstone depression mentioned above, and takes a northeasterly course. In crossing the county the waters of this stream descend several hundred feet and the changes in the character of the rocks along its course have resulted in concentrating this fall at a number of points. Two or more of these shoals occur in the gneissic area near the border of the sandstone depression mentioned above, where the river makes its final descent from the elevated area of harder rocks into this basin. A similar condition of things exists on the Mayo and Smith rivers in Rockingham county, which, like the upper part of the Dan river, rise in Virginia, flow across the plateau of harder gneissic rocks in a southeasterly course and join Dan river in Rockingham county as it flows along this sandstone depression. The waterpowers developed on these two streams at Mayodan and Spray (pp. 111 and 109) have their origin in the sudden descent of these streams from the more elevated surface of the harder rocks into the sandstone basin at these points.

ON THE SOUTH FORK OF CATAWBA AND LINVILLE RIVERS.

Two other streams occurring in this general region may be mentioned here as of special interest though, like those just mentioned, not typical of conditions developed in gneissic and granitic areas. One of these, the south fork of the Catawba, which from Lincolnton to the mouth of the river crosses mainly rocks of a slaty and schistose character and nearly at right angles to their strike, has been briefly described already (p. 83).

The other, the Linville river, rises on the northwest slope of the Grandfather mountain and for a distance of more than ten miles flows in a southerly course just west of the crest of the Blue Ridge, which it crosses on the boundary line between Caldwell and Mitchell counties, and from this point for more than 15 miles it flows southward as a succession of falls, cascades and rapids, cutting its way through the Linville quartzites, which cap the Blue Ridge in this region, into the underlying typical gneisses. In this distance of 15 miles the descent of the river averages nearly 100 feet to the mile. The Linville joins the Catawba river in the gneissic area some 10 miles west of Morganton (p. 220).

ON THE YADKIN AND CATAWBA RIVERS.

The conditions favoring the development of waterpowers in granitic and gneissic areas have been described briefly above (p. 72), and the cascades and shoals and rapids on the Yadkin and Catawba, as well as on the tributaries of the Broad, will generally be found to have their origin in local changes in the character of the rock, in one or another of the ways there suggested. All of the conditions there described are to be found illustrated at intervals in this region.

As will be seen from the maps and descriptions given in a subsequent chapter, the shoals on the upper Yadkin, which lie within the area now under consideration, are less numerous than those on the same stream in its course across the belt of slate and schist already described. And inasmuch as the changes in the character of the rock in the region of the upper Yadkin are for the most part not radical, the amount of the fall at each of the shoals is less great than in the slate belt. This fact, together with the diminishing volume of water as we ascend the stream, render the powers on the upper portions of this stream less important.

The Catawba river, which, like the Yadkin, rises along the crest and eastern slope of the Blue Ridge, flows nearly a hundred miles in a northeasterly course and then turns southward. Its course in North Carolina lies entirely within the gneissic and granitic area. From Morganton eastward for a distance of nearly 40 miles the river either parallels the general strike of the rocks or crosses it obliquely. The changes in the character of these rocks are not numerous, and the number of shoals correspondingly small, though several of them are of considerable magnitude. The river then runs in a southeasterly and southerly direction for a distance of but little more than 25 miles; but in this distance it crosses the course or strike of the rocks at right angles. The changes in the character of the rocks are numerous, the rocks even being schistose and slaty in places, and the stream is literally a succession of shoals, the aggregate fall being not less than 175 feet. At a point some 10 miles south of Statesville, as will be seen on the small map (p. 78), the river reaches the typical granite belt of this region and flows thence southward for a distance of approximately 40 miles, where it crosses the state line into South Carolina. In this part of its course the rocks of the region are again more nearly uniform, and though there are several shoals of importance, as those at Cowans ford, Mountain Island, and Tuckaseegee, yet the number of these shoals in proportion to the distance is much smaller than in the 25-mile section next above.

ON THE TRIBUTARIES OF BROAD RIVER.

Among the tributaries of the Broad in Cleveland and Rutherford counties, the streams descend rapidly from the South mountains along the upper border of these counties down to the general plain of the Piedmont plateau, flowing in a southerly and southeasterly direction nearly at right angles to the general strike of the rock, and in this way encountering the greatest number of changes in the character of these rocks, which results in conditions most favorable for the development of waterpower. Hence it is that we have in this region a large number of valuable waterpowers, some half dozen of which are already operating cotton-mills, while others are soon to be utilized in the same way.

CONDITIONS IN THE SLATY AND GNEISSIC AREAS COMPARED.

In any study of the streams and waterpowers of the Piedmont plateau region it should be borne in mind that while the slaty belts present more favorable conditions for developing waterpowers, as shown in the case of the Yadkin (p. 71) and the other streams which cross the several belts, owing to the fact that in these belts the sheets of rock stand more on edge and vary more in hardness and durability, yet the streams which draw their supplies from the granitic and gneissic areas are more uniform in their flow for the reason that while the rainfall in the different belts is approximately the same, the soils in the granitic and gneissic areas are deeper and more porous and serve more as a sponge for storing up the surplus water of rainy seasons than does the more shallow and compact clayey soils resulting from the decay of the slates. This is one of the principal causes why the flow is less uniform in the case of the Haw and Deep rivers (pp. 144 and 157), which lie largely in the slaty belt, than in the case of the Yadkin and Catawba (pp. 172 and 203) which lie almost wholly in the granitic and gneissic areas.

WATERPOWER IN THE MOUNTAIN REGION.

A glance at the accompanying small geologic map (p. 78) will show that the larger part of this region is occupied by gneissic rocks. These have for the most part a characteristic northeast and southwest strike, and the irregular sheets of rock dip beneath the surface at varying but generally steep angles. The southern half of the region has along its western border an irregular belt of bedded slate, limestones, quartzites and conglomerates; and these rocks, which make up the bulk of the Great Smoky mountains, have a general northeasterly strike and dip at steep and varying angles. Near the eastern border of the region there is another but more narrow and irregular belt of rock of a somewhat similar character, following approximately the general position of the Blue Ridge mountains.

The general physiographic features of the region are briefly described on a preceding page (p. 25), but it may be restated here that the rivers of this region have their sources mainly along the western slope of the Blue Ridge, and that with the exception of New river, near the northern boundary, they flow in a general northwesterly direction across the upturned edges of both the gneissic and the more recent bedded rocks. The elevation of the country is so great and the descent of the streams so rapid that the general courses of the principal rivers have been but little modified by geologic structure, though their courses lie directly across the strike of the rock; and the resulting conditions are such as to produce along the streams occasional rapids and cascades. Especially would this be the case in the western counties, where the Pigeon, the Tuckaseegee, the Little Tennessee and the Hiwassee break through the Great Smoky mountains, and in doing so cross a variety of limestone, quartzite and conglomerate beds which go to make up the geologic formation of that area, but for the fact that during the long period of time that these streams have occupied their present channels, owing to the rapidity of their flow and the large quantities of abrading materials, such as sand, gravel and bowlders, carried down in their currents, the variations in the obduracy of the rocks crossing these stream beds seldom result in cascades of large proportions, for the reason that the would-be projecting ledges of rock across the stream bed are kept down near the general level by these eroding agencies.

A number of the smaller tributary streams flow in either a southwesterly or a northeasterly direction along the line of the strike of the rocks and thus develop the conditions favorable for waterpowers, mainly where they vary their courses and cross from rock of one character to one of a different character. In the extreme northern portion of the region the tributaries of New river rise both on the western slopes of the Blue Ridge and the eastern slopes of the Iron mountains, and flow in a general northeasterly or northerly direction, sometimes following the line of the strike, and sometimes crossing the latter at sharp angles. Along New river and its tributaries are a number of shoals which can be developed into valuable waterpowers, occurring mainly at points where the streams cross the strike of the gneissic rock of the region.

In connection with the development of these waterpowers, the river gorges are so narrow and the streams so rapid that while the construction of large dams is a matter attended with no insurmountable difficulties, yet it is often difficult to find suitable space for buildings, and it has been found more advisable in a number of cases to construct small dams and to convey the water from these in open ditches or flumes along the banks of the stream to suitable points where the power may be utilized. The chief difficulty which is met in storing water on these streams is that the ponds or storage reservoirs become rapidly filled with sand, gravel and bowlders brought down in time of flood. Probably the future development of these powers will be largely by electrical transmission, which is described more fully in a succeeding chapter (p. 337).

PART II

WATERPOWER IN NORTH CAROLINA EAST OF THE BLUE RIDGE

GEO. F. SWAIN
AND
J. A. HOLMES

WATERPOWER IN NORTH CAROLINA EAST OF THE BLUE RIDGE[1]

CHAPTER V.

THE ROANOKE RIVER AND TRIBUTARIES.

THE ROANOKE RIVER.

This river is formed by the confluence of the Dan and Staunton rivers, in Mecklenburg county, Virginia. Thence flowing southeast it enters North Carolina in Warren county, and forms the dividing line between Halifax and Martin counties on its right, and Northampton and Bertie on its left, emptying into Albemarle sound just above Plymouth. The total length of the river is about 125 miles in a straight line, and probably nearly twice as far by the river. The principal towns on the stream are: Clarksville, Virginia (at the junction of the Dan with the Staunton), Weldon, Halifax, Hamilton, Williamston, and Plymouth, North Carolina. The stream is navigable at low-water to Weldon (some 120 miles), or can be made so for boats drawing 2 or 3 feet, and to Hamilton (60 miles) for boats drawing 10 feet. Boats of greater draught cannot come through the sound. It is considered possible to get a low-water navigation of 5 feet to Weldon,[2] the principal obstacles to navigation being snags, stumps and sand-bars. By a system of locks and dams this river, with the Dan, was long ago made navigable to Danville, more than twice as far from the mouth as Weldon, but these old canal-works have been long in disuse. Although Weldon is now the head of navigation, yet there are still long reaches on the Roanoke and on the Dan, both above and below Danville, which are boatable.

The total area drained by the Roanoke river comprises about 9200 square miles, of which the Dan drains 3798, the Staunton 3546, and the Roanoke below the junction 1856. There are no large tributaries of the Roanoke below the confluence of the Dan and Staunton.

The drainage basin of the Roanoke proper is divided into two nearly equal parts by the fall line, which crosses the river between Weldon and Gaston. That part of the watershed below Weldon is low and flat, and partakes of the general characteristics of the eastern division. Above Weldon the country is more broken and the river has more fall, having cut its bed down to the underlying metamorphic rocks. The drainage basin is long and narrow, varying in width from 10 to 30 miles, and along the river are many fine bottoms, among which are some of the best farming lands in the vicinity. The bottoms widen out as we descend the river, and the flood-plain spreads out in places to a width of several miles, and finally is represented by the broad lowlands and cypress swamps of the eastern division. Alternating with the bottoms are bluffs, especially on the south side of the river. The proportion of the drainage basin covered with forests we have not been able to ascertain. The soil is clay and loam, with sand in the lower part of the basin, and the productions are tobacco, cotton, corn, wheat, fruits, and vegetables.

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[1] From the original report of Geo. F. Swain, published in the reports of the Tenth Census, with data revised and brought down to date, by J. A. Holmes.

[2] Annual Report, Chief of Engineers, 1872, p. 726; 1879, p. 624.

Below Weldon the country is quite heavily timbered, and large quantities of timber and shingles are shipped. It is said that between 15,000,000 and 20,000,000 shingles are made and shipped annually from this region. Above Weldon fine building stone is found in many places, and in Granville, Warren, Edgecombe, and Wilson counties, North Carolina, a fine quality of granite is occasionally quarried. Near Gaston there is a deposit of specular iron-ore, which has been very little worked. The basin is thinly settled above Weldon. The Raleigh and Gaston railroad, after leaving the river at Gaston, recedes rapidly from it, and afterward comes nowhere within 8 or 10 miles of it; while on the north the river is crossed by the Atlantic and Danville and Southern railways near Clarksville, and will probably be crossed between Clarksville and Gaston by a new line of railway recently projected from Ridgeway to Petersburg.

The average rainfall on the watershed of the Roanoke above the fall line is probably 40 or 42 inches, varying from 38 or 39 on the upper part of the Staunton to 44 inches at Gaston. Of this amount 10 or 11 inches fall in spring, about 10 inches in summer, and nearly the same in autumn and winter. Being so uniformly distributed, the flow of the stream may be expected to be very variable, especially as in all probability the evaporation is quite large; and, in fact, the general testimony is that the flow of the stream is subject to large variations.

The freshets on the river are very violent, and the fluctuations often occur very rapidly. At Weldon an ordinary freshet gives a rise of 12 or 15 feet; but generally twice in the year, in the spring and in the fall, there is a larger freshet, the water rising 25 to 30 feet. In 1865 the river rose 50 feet at that point, and 30 feet at Hamilton. For 60 or 70 miles below Weldon the rise is from 10 to 30 feet, but it gradually diminishes as the mouth of the river is approached, and for the last 15 or 20 miles of its course it is from 1 to 3 feet.[1] These floods occur so rapidly that the river rises sometimes over 10 feet in a day at Weldon,[2] and where there are no dikes it occasionally overflows the banks and inundates large areas of the adjoining lands. Daily measurements of the height of the river surface have been made and recorded at Clarksville and Neals for several years, and occasional measurements of the flow have been made at both these places. A record of these will be found in Part IV (pp. 287 and 292) of this report.

There are no lakes or artificial reservoirs anywhere in the drainage basin, neither are there facilities for storage on the Roanoke proper; but on the upper Dan and Staunton reservoirs might doubtless be constructed at many points.

The bed of the stream is generally sand below Weldon, with one or two ledges, and the banks are alluvial, not very low as a rule, and in many places lined with overhanging trees; while above Weldon the bed is generally composed of solid rock, sometimes of gravel and sometimes of sand or clay, the banks being alternately high and sometimes bluffy, and low and alluvial. Above the falls at Weldon, which extend for a distance of 10 miles above that place, the river is wide, full of rocks and islands in many places, and difficult to navigate in low water, with large areas of bottom-land subject to overflow in freshets, although the rise is smaller than at Weldon. Large areas of these lowlands below Weldon were diked before the Civil War to prevent flooding of the cultivated areas, and in places these dikes are being kept up at the present time. High dams across the river, except between Gaston and Weldon, would, in general, be accompanied by the overflowing of large areas.

The following table will give some idea of the fall of the stream:

TABLE OF DECLIVITY—ROANOKE RIVER.

PLACE.	Distance from mouth.	Elevation above tide. (Approximate.)	Distance between points.	Fall between points.	Fall between points.
	Miles.	Feet.	Miles.	Feet.	Feet per mile.
Mouth	0	0	120	44	0.36
Weldon	120	44	9	84	9.3
Head of falls	129	128	56	141	2.52
Clarksville	185	269			

In the twenty-second report of the board of public works of Virginia is a report on a survey of the Roanoke, by J. J. Couty. It is there stated that the fall from Rock Landing, in North Carolina, to the confluence of the Dan and Staunton, in Virginia, is 156.65 feet, the distance being 59.9 miles. The same report states that the width of the river is considerable, being even three-fourths of a mile in places, but on the average about 400 yards, and that the bed is mostly of solid rock, and remarkably favorable for dams.

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[1] Annual Report of the Chief of Engineers, 1872, p. 726.

[2] Annual Report of the Chief of Engineers 1876, Appendix G, 9.

The *waterpowers* on the stream will now be described.

WATERPOWER ON THE ROANOKE NEAR WELDON.

The first power on the river as it is ascended is that at Weldon, North Carolina, where the stream crosses the fall line. The fall here is about 84 feet in a distance of 9 miles above the town, the river within this distance being very rocky and rapid, the channel very tortuous, and the bed of the river interspersed with rocks and islands, most of which are submerged at high water. Some of the larger islands are cultivated. The bed of the river is almost solid rock, and the banks generally abrupt, especially on the upper part, for several miles below the head of the falls, where they are 40 or 50 feet high, of hard granitic rock, and often extending almost perpendicularly to the water's edge. Waterpower development has been in progress here for several years by the two companies mentioned below. The accompanying map (Plate II) shows the relative location of these developments and its contour lines—with a 20-foot interval between them—indicate the general topography of the region.

Roanoke Navigation and Waterpower Company's Canal.—Some fifty years ago the Roanoke Navigation Company extended navigation around these falls by constructing a canal on the south side of the river between Weldon and Rock Landing, 9 miles above. This canal was 30 feet wide at the top and 3 feet deep, dimensions sufficiently large for the boats then in use on the river. As a navigation enterprise this was probably never a great financial success, and with the building of railroads to Petersburg and Norfolk, the upper river navigation declined steadily until it was finally discontinued, and the works were allowed to fall into disuse, the canal being kept open only sufficiently to supply water necessary to run one or more small mills. The General Assembly of 1874-75 authorized the dissolution of the old Roanoke Navigation Company and ordered the sale of the property which was subsequently purchased by the Roanoke Navigation and Waterpower Company. This company subsequently cleaned out and repaired the canal and has begun its development as a source of waterpower.

The canal was originally substantially built, and crosses several small

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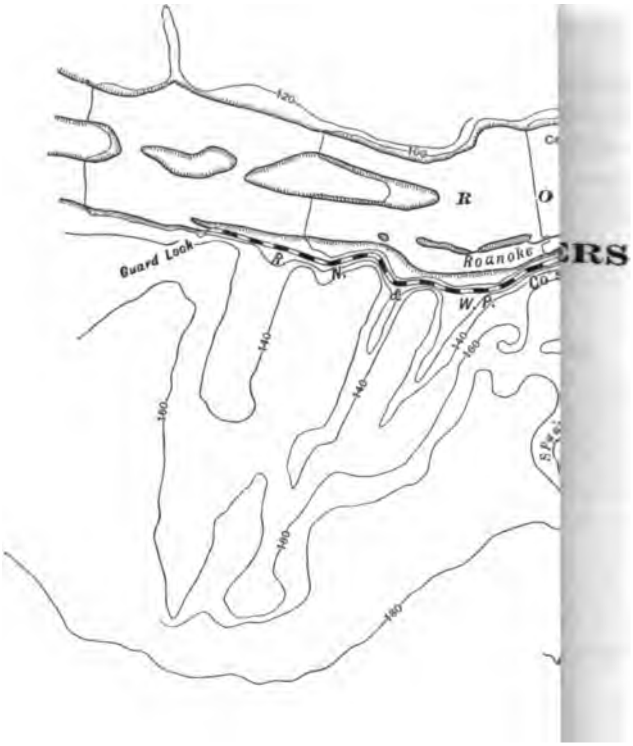

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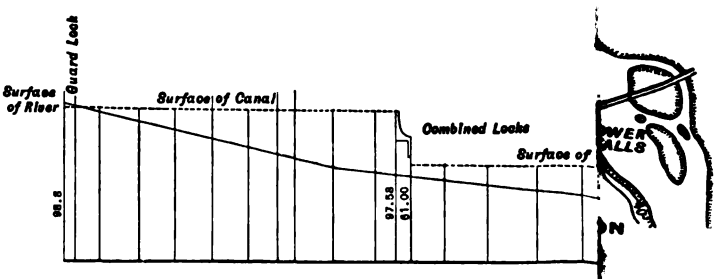

Profile along the Roanoke Navigation and Watc

O.,N.Y.

creeks by means of stone aqueducts, all of which, as well as some of the locks, which were also of stone, are in good condition, although the gates of the latter are gone; and toward the upper end of the canal there are extensive masonry walls in places on the river side, rendered necessary by the abruptness of the banks, all of which are in good condition. At the upper end of the canal there was a guard-lock, and probably a dam, but the gates of the lock are gone, and the dam now there consists only of a few stones piled up roughly. The river at this place is said to be very favorable for the construction of a dam which might extend entirely across the channel.

Nearly four miles below the head of the canal is a flight of four locks with a total lift of 36 feet. The total fall at these locks now available for power is 31 feet. The land in the vicinity is favorable for building. See "combined locks" (Plate II).

At the lower end of the canal a fall of 48 feet between the level of the canal and the river was overcome when the canal was used for purposes of navigation by a flight of 6 locks with 8 feet lift each.[1] These locks have since been abandoned and removed. At the lower end of the canal the company has erected a corn-mill having a daily capacity of 2000 bushels with a grain elevator of 50,000 bushels capacity attached, and a cotton-seed oil mill with a capacity of 35 tons per day of 24 hours; the two mills using about 250 horsepower, the total available low-water fall for power at this point being 45 feet. The company has recently added a cotton-gin and a baling plant for the new cylindrical bale.

These mills discharge the water directly to the river, and are situated from 100 to 200 yards above the old locks. They can run full capacity all the year, except occasionally, for a few days at a time, when their running is interfered with by high water. There is practically no trouble whatever from ice.

The recent development which was completed a few years ago, consists of the enlargement of the prism of the original canal to the following dimensions, to wit: "Twenty-three feet at bottom, thirty-five feet wide at normal surface of water, and four feet deep; the construction of head-gates, with the necessary masonry, the raising and repairing of waste-ways and waste-gates, the construction of a waste-weir and gates at the foot of the basin in Weldon, the raising and repairs of the masonry of Chockeotte creek aqueduct, and the raising and strengthening of the banks of the canal throughout its length.

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[1] Report of Roanoke Navigation Company in one of the reports of the board of public works of Virginia.

"The canal, with the foregoing dimensions, with smooth surfaces, and with a bottom grade of one foot per mile, as it has been constructed, has a capacity to carry 15,550 cubic feet of water per minute.

"It is constructed in two reaches or levels, the first or upper one extending from the head-gates to the combined locks, a distance of about three and a quarter miles, securing a fall of thirty-one feet at said locks. The second level extends from said locks to the terminus of the canal at Weldon, a distance of about five and one-eighth miles, where a fall of forty-five feet can be secured when the water in the river is at low-water stage."[1]

The total drainage area of the Roanoke above Gaston, or the head of the falls, is about 8200 square miles, and the rainfall over this area is about 40 or 42 inches, distributed tolerably evenly throughout the year. Records of only recent gaugings of the river are to be had. W. C. Kerr measured the flow at Haskins' Ferry, over 50 miles above Weldon, in the fall, and found it to be 2950 cubic feet per second, the drainage area above this point being about 7350 square miles, but the stage of the river is not stated. Swain has estimated the flow of the river at Gaston to be as follows:[2]

	Cubic feet per second
Minimum flow[3]	1,500
Minimum average for low-season flow	1,700
Average for the low-season flow of average dry years	1,950

The corresponding power may be tabulated as follows:

Flow, cubic feet per second.	Horsepower available, gross.		
	1 foot fall.	33 feet fall.	84 feet fall.
1,500	170	5,610	14,280
1,700	193	6,369	16,212
1,950	221	7,293	18,564

The second column of this table will also indicate the power that might be expected to be developed at the locks were the canal above this point sufficiently enlarged to allow the entire river, at low water, to flow through it to this point. This large power, only partially utilized, is available, although it would be very expensive to utilize the whole of it.

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[1] Report of Byron Holly, civil and hydraulic engineer to the Roanoke Navigation and Water-power Co., 1892, published in the *Prospectus* of that company.

[2] For later measurements of the flow of this river, see pp. 292-294.

[3] See pp. 54-58.

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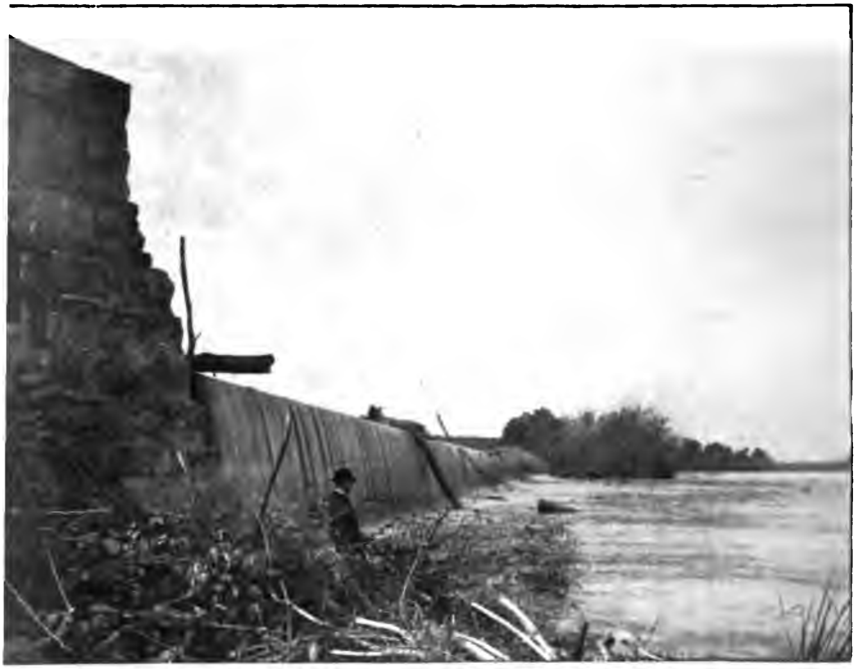
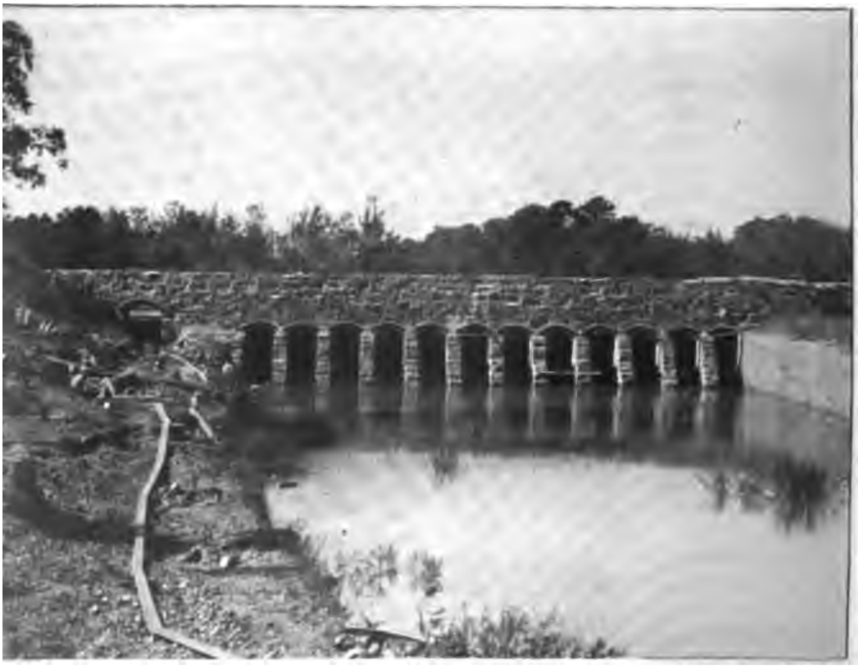


A DAM ADJOINING THE BULKHEAD, ROANOKE RAPIDS CANAL



B—BULKHEAD TO THE ROANOKE RAPIDS CANAL

The powers given in the above tables could be rendered available without much difficulty, but it must be remembered that all the power calculated thus far is the gross horsepower, and that the amount to be practically utilized would be less, varying according to the motor employed. With good turbine-wheels the net power will be about three-quarters or eight-tenths of the gross power.

The power at Weldon is one of the largest in the state of North Carolina, and the principal cause of its not being utilized to a greater extent until recently is probably the lack of capital. The facilities for transport are excellent, both by land and by water, for the river can be made navigable up to the town, and it is quite a railroad center. Four railroads terminate in the town, viz. the Petersburg Railroad, the Seaboard and Roanoke Railroad, the Wilmington and Weldon Railroad, and the Raleigh and Gaston Railroad, thus bringing Weldon within less than 2 hours of Petersburg, less than 3 hours of Richmond, Raleigh and Norfolk, 5 hours of Wilmington, 8 hours from Washington, and 12 hours from New York.

Good building-stone and timber can be obtained in abundance in the neighborhood, and a good deal of cotton is raised in the vicinity. The iron deposits near Gaston have only been worked to a very small extent, although the ore is said to be of good quality. The advantages for the utilization of the power are in fact excellent in all respects, and that there are no serious drawbacks is proved conclusively by the successful operation of other manufacturing plants in this region. This magnificent power is worthy of a careful examination by capitalists.

ROANOKE RAPIDS CANAL.—The development work of this company also lies on the south side of the Roanoke river, between Weldon and Gaston, beginning 1½ to 2 miles below the upper end of The Roanoke Navigation and Waterpower Company's canal and terminating nearly 2 miles below in the great bend of the river, where the factories are located. As shown by the accompanying map (Plate II, p. 94), the upper one mile of the canal lies between the right bank of the river and a chain of islands which are connected by dams made of wood and stone. The longer of these connecting dams has a length of 1465 feet and a height of from 4 to 7 feet, and the dam (Plate III) connecting the lower end of the lowest island with the outer end of the bulkhead is 685 feet long and about 11 feet high, built of log frame with rock filling and planked above. Along the surface of these islands dikes are thrown up to prevent the overflow of water from the canal into the river.

The bulkhead (Plate III) is of stone, 150 feet long, 24 feet high, at its outer or northern end, and 15 feet thick, and is penetrated by 13 gates for the admission of the water into the lower part of the canal. This lower part of the canal is three-quarters of a mile long from the bulkhead to its lower end, 90 feet wide at top, 60 feet wide at bottom, 10 feet deep, and when the canal contains its normal supply of water its cross-section below water surface is 7500 square feet. The fall at the lower end of the canal during ordinary seasons is said to be 27 feet. In dry seasons the fall is 30 feet, and the capacity of the canal is then said to be 6100 horsepower. Only a small part of this power is being utilized at the present time, but two substantial factories have been constructed and are now in operation.

The knitting mill of the United Industrial Company, located immediately against the side of the canal, contains 2310 spindles, 5 sets of cards, 30 knitting machines and 75 sewing machines. Its power is developed by 2 Leffel 40-inch turbine-wheels on a horizontal shaft, supplied with water by an iron penstock direct from the canal, and capable of developing, it is claimed, with the dry season head of 30 feet, about 800 horsepower. Of this, however, only about 150 horsepower is being used.

The cotton-mill of the Roanoke Mill Company, located about 100 yards east of the above and at a slightly greater distance from the canal, has a capacity of 18,000 spindles and 550 looms, though it has now in operation only 12,096 spindles and 320 looms, and it is using only about 400 horsepower, though its two McCormick 36-inch turbines, on a horizontal shaft, with a normal waterhead of 28 feet, are said to develop 640 horsepower. The water is supplied to these wheels by an iron penstock 9 feet in diameter and 480 feet long. A smaller single turbine, said to be capable of developing 125 horsepower, supplies power for the electric lights, fire pump, etc. As will be seen from the above statement, there is here ample power for additional manufacturing establishments, and until it is fully utilized there need be no fear of a scarcity of water during dry seasons, and there will be but little trouble from high water except during the larger freshets.

Above Gaston the river widens, and there are no other powers at all comparable with the one just described, although there are some shoals which might advantageously be utilized, alternating with long boatable stretches of smooth water. In regard to these shoals, however, we were only able to obtain a few scattered notes, and on account of their inaccessibility were unable to visit any of them.

Four miles above Rock Landing, the head of the Weldon canal, is a shoal, around which the Navigation Company constructed a canal 400 yards long, with a lock at the lower end having a lift of 9 feet.

Two miles further up there is a second mill, and above that are several others, tabulated in the table of utilized power. The available fall, however, we are unable to state. The only other place on the river where the Navigation Company found it necessary to construct a canal was at Pugh's falls, where there was one lock with 5½ feet lift,[1] but we are unable to say just where this place is located. We are also unable to give any information regarding the present condition of these canals, but the probability is that they are in very bad order.

The principal reason why these shoals have not been used more extensively is probably the fact that the river is wide, so that the dams necessary are long and expensive and subject to injury by the freshets. Of necessity, therefore, mills have usually been located on smaller streams.

Finally, it may not be out of place to say a few words regarding the causes of the low flow of the Roanoke (estimated), as compared with that of streams in New England. These causes are probably the following: (1) The rainfall on the drainage basin is not greater, and probably rather less, than on the basins of New England streams; (2) it is, on the whole, tolerably uniformly distributed throughout the year, but on some parts of the Dan and Staunton rather more falls in winter than in summer; hence, as the evaporation is very large, the streams will be very low in summer, when the evaporation is greatest and the rainfall least; (3) there are no lakes to regulate the flow.

THE ROANOKE TRIBUTARIES—DAN RIVER.

In regard to the smaller tributary streams of the Roanoke in North Carolina very little is to be said. None of them are of any importance, and possess no large waterpowers, so far as we could learn. The only power used on them is for running small grist- and saw-mills, the grist-mills generally with one, two, or three run of stones. We visited none of these streams, and the tables of the power utilized on them, compiled from the reports of the enumerators, will show that they are not of much consequence. For small powers they can be economically utilized—more economically than the Roanoke itself—because they have more fall, because the cost of a permanent dam is less, and because the mills are not troubled with high water, as those on the Roanoke are; but their flow is, of course, much more variable than that of the Roanoke.

The Dan river, one of the main forks of the Roanoke, rises in Patrick county, Virginia, near Buffalo Knob, in the Blue Ridge. It flows first in a southeasterly direction, enters North Carolina, flows through Stokes and Rockingham counties, and, pursuing a general easterly course, enters Virginia in Pittsylvania, returns to North Carolina in Caswell, and finally enters Virginia again in Halifax, to unite with the Staunton in the adjoining county of Mecklenburg, forming the Roanoke. The length of the stream, measured in a straight line nearly east and west, is about 100 miles, and by the course of the river about 180 miles. The principal towns on the river are Danbury, Madison, and Leaksville, North Carolina (all small towns of several hundred inhabitants); Danville, Virginia, with a population of over 15,000; Milton, North Carolina, and South Boston, Virginia, with five or six hundred inhabitants each.

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[1] Report of Roanoke Navigation Company in one of the reports of the Virginia board of public works.

As has already been stated, the river was many years ago made navigable by the Roanoke Navigation Company as far as Danville, and for 50 or 60 miles above that place (as far as Sauratown) for bateaux carrying 12,000 pounds, and at times bateaux have reached Hairstons falls, 12 miles below Danbury. Boats propelled by poles now ply irregularly between Danville and various other points on the river.

The river and harbor act of June 18, 1878, provided for a survey of the river from Clarksville, Virginia, to Danbury, North Carolina, and the reports on this survey by Mr. S. T. Abert, United States civil engineer, are to be found in the reports of the Chief of Engineers, 1879, p. 652, and 1880, p. 794. These reports give detailed information regarding the river, and have been used freely in the present report. By the river and harbor act of June 14, 1880, the sum of $10,000 was appropriated for the improvement of the river between Madison, North Carolina, and Danville, Virginia, "the object being to afford a channel for steam navigation not less than 35 feet wide, and not less than 1½ feet deep in the pools and 2 feet deep in the rapids at extreme low water," the estimated cost of the work being $52,000.

The total area drained by the Dan is 3798 square miles. The table on page 106 gives the drainage areas above the principal waterpowers.

The principal tributaries to the river are, from the north, going up the river, Bannister river, Birch creek, Sandy river, Smiths river, and Mayo river; from the south, going up, Hyco river, County-line creek, Moons creek, Hogans creek, and Town fork. These will be referred to again.

The drainage area of the Dan lies in the Piedmont division of North Carolina and Virginia, the sources of the river being on the eastern slope of the Blue Ridge. Its general character does not differ, as a whole, from that of the middle division, which has been described on a previous page. Its shape and dimensions may be seen by referring to the accompanying map. Geologically, it lies in the area of metamorphic rocks. Granite is found at various points; also sandstone, limestone, and slate, and fine building-stone is to be had in abundance. The valley contains coal and iron deposits, extensive beds of iron-ore, which have been worked to some extent for more than half a century, occurring near Danbury, North Carolina. The coal-fields embrace an area of over 30 square miles, and have been developed only to a very small extent. Some of the coal has been found of inferior quality, but doubtless as other openings are made coal will be found which is available for manufacturing purposes.

The watershed separating the valley of the Dan from those of the Yadkin and Cape Fear is a "long and broad ridge or swell of land, which trends due east," with an elevation of 800 feet and upward. The bed of the river is generally 200 or 300, and sometimes 400, feet below the adjacent ridges, and its tributaries have, therefore, very considerable fall, some of them affording very fine waterpower.

The principal products of the valley are tobacco, corn, wheat, rye, oats, potatoes, and fruits. There is very little, if any, cotton grown in the valley. "Between Danbury and Leaksville the land appears to be best adapted to tobacco culture, and a fine grade is produced, although there are some short stretches of very good bottom-land. Further down, the valley widens, and broad bottoms are found cultivated in corn and wheat." The country is hilly and undulating, and in the extreme west mountainous. The forests above Danville are extensive and valuable.

There are no lakes in the basin, but much of the region is forest-covered, and artificial storage-reservoirs could probably be located at many points.

The bed of the river is solid rock, overlaid between the rapids with sand and gravel. The facilities for dams are excellent. Above Danville the banks are generally moderately high, and sometimes abrupt and bluffy, and the bottoms narrow, and not often overflowed. Below Danville the banks are lower, the bottoms wider, and oftener overflowed, and bluffs more rare. There are no regular ravines of any extent, a bluff on one side of the river being generally faced by shelving or low ground on the other.

The river is subject to heavy floods, the river rising and falling very rapidly. At Madison, in 1850, it rose 28.4 feet; and at Danville, in 1873, 17 feet above ordinary low water. Below Danville the floods rise still higher. Thus, in November, 1877, the river rose to heights of 30.21 feet above low water at Milton; 33.54 feet at Oliver's mill, 28 miles below Danville; and 23.7 feet at Clarksville. Such rises are, however, very rare. There is seldom any trouble with ice, and ice-jams occur very seldom, although the river is sometimes frozen over. "Notwithstanding the height of the floods, the banks are seldom washed, their permanency being secured by a fringe of willow-growth, which borders the low grounds."

The average annual rainfall on the valley of the Dan is about 43 inches, distributed approximately as follows: spring, 11; summer, 12; autumn, 10; winter, 10. In the upper parts of the valley the rainfall is as follows: spring, 12; summer, 14; autumn, 10; winter, 14 inches. The following table will show the declivity of the stream:

TABLE OF DECLIVITY—DAN RIVER.

PLACE.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	Feet.	Miles.	Feet.	Feet per mile.
Clarksville	0.00	269	64.27	121	1.88
Danville, Southern railroad crossing.[1]	64.27	390	50.10	157	3.13
Madison bridge	114.37	547	14.94	52	3.49
Hairstons ford	129.31	599	13.45	95	7.28
Danbury ford	142.76	695			

Having no long-continued records of gaugings of the Dan river, Swain has estimated the flow. The following estimates are for the mouth of the stream:

TABLE OF ESTIMATED FLOW AND POWER OF THE DAN RIVER AT MOUTH.[2]

State of flow.	Drainage area.	Flow per second.	Horsepower available, gross.
(See pages 54 to 59.)	Sqr. miles.	Cubic feet.	Per foot fall.
Minimum	3,798	700	80
Minimum low season		810	92
Low season, dry years		950	108

The Dan river for a long time was not very accessible above Danville. Below that point the Richmond and Danville railroad is within 4 miles of the stream for about 50 miles, after which it leaves the river nearly at right angles. The Atlantic and Danville railroad also runs within a few miles of the river all the way from Danville to Clarksville. Above Danville the river is for about 30 miles within 6 miles of the railroad, but above that it was quite inaccessible. Thus the part of the stream which was easily accessible was between the mouth of the Bannister river and the town of Leaksville. The building of the Cape Fear and Yadkin Valley railroad to Madison, the Roanoke and Southern railroad from Winston to Roanoke, and the Leaksville Narrow Gauge railroad now render that part of the river above Danville as accessible as that below, and this is doing a great deal to develop the resources of the region.

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[1] The elevations on the Richmond & Danville (Southern) railroad were furnished by T. M. R. Talcott, then general manager, who had special measurements made of the height of the track above the water-surface.

[2] For measurements of the flow of Dan river see pp. 288, 289.

WATERPOWER ON DAN RIVER IN NORTH CAROLINA.

It has already been stated that the average fall of the Dan between Clarksville and the Richmond and Danville railroad bridge is 1.88 feet per mile. This fall is, however, not evenly distributed over the whole distance, but is mainly concentrated at a few localities, thus affording opportunities for developing large waterpowers. The only one of these in North Carolina, however, is that at Milton.

Concerning the **Milton shoal**, it may be said that the fall is moderate in the upper 4100 feet, but for the remainder of the length very rapid, and the river is full of islands and rocks. Below the shoal the river is only 120 feet wide for a distance of three-quarters of a mile. The fall in the river from the head of Dodsons shoals to the mouth of Countyline creek at Milton is 7½ feet in a distance of 1½ miles. The conditions for building a dam on Dodsons shoals are said to be good, and a six-foot dam would give a fall of 13½ feet. The conditions for locating and constructing a canal between the two points are said to be exceedingly favorable, and the conditions for locating factory buildings at Milton are said to be equally satisfactory. Two lines of railroad (the Atlantic and Danville and the Southern) at Milton give excellent transportation facilities.

The next shoal of importance is the **Danville shoal**, just below the Richmond and Danville railroad bridge, and nothing more than a continuation, with a less rapid fall, of Danville falls. The bottom is wholly rock.

In regard to the amount of power which can be utilized on the river between Danville and Clarksville, an opinion could only be formed by a personal examination. From what has been said, it is clear that there would be no difficulty in building dams almost anywhere, so far as the bed of the stream is concerned, and the banks are much more favorable than on the Roanoke; but whether much of the fall is available for power, at reasonable cost, we cannot say. In the table are given estimates of the power at only a few points. The powers given for the separate shoals are for the natural fall in the river at each shoal, and may, of course, be increased if that fall is increased by a dam.

Proceeding up the river, various shoals are encountered, all of which are mentioned in the following table. As before, the power has been calculated only for the principal ones. We are unable to describe in detail any of these shoals, not having visited any of them in person. It is evident, however, that the facilities for power are good, as far as bed and banks are concerned, both from Mr. Abert's report and from what additional information we could gather. The width of the stream between Danville and Madison varies from 190 to 430 feet, averaging perhaps 250 feet. At Hairstons ford, above Madison, it is 160, and at Danbury 120 feet. The power of the river at the time of this enquiry was utilized between Danville and Danbury at only two points, viz. at Eagle falls and at Hairstons falls, and there only by small grist- and saw-mills, using a very small amount of power. The mill at Hairstons falls was supplied by a dam at the head of the falls, extending in the form of a V across the stream, with the apex up stream, and constructed of logs. It was built in 1879, at a cost of about $125, and is about 150 yards (?) long and 3½ feet high, backing the water about half a mile. A race about 2000 feet long leads to the mill, located on the right bank, where a fall of 9 feet was used with a primitive wheel to drive the grist- and saw-mill, some 20 horsepower (net) being utilized, and in dry weather no water flowing over the dam. The bed of the river is solid rock.

A power just above Danbury was formerly used to a small extent by the iron works at that place. The dam was 10 feet high, and the water carried to the works through a tunnel about 100 yards long, cutting through a spur of the hills around which the river bends, and affording at the lower end of the canal a fall of 21 feet. The fall used by the works was about 16 feet, and the distance from the head of the canal to the foot of the tail-race about half a mile by the river. A very small proportion of the dry-weather flow of the stream was utilized. The works have not been in operation since 1865, and the dam has been entirely washed away. It is said that a dam 18 feet high could be built at this place, in which case the available fall, at the lower end of the canal, would be 29 feet.

Above Danbury the Dan is a small stream, but has a great deal of power, on account of its rapid fall. We can form no estimate of its available power, but it is safe to say that sites for small mills can be found at numerous points all the way up. The utilized power is tabulated below.

The results in the tables below must only be considered as very rough approximations, but we believe the powers given to be rather too small than too great. When it is remembered that the rainfall records for the region considered are very incomplete indeed, so that its distribution through the year is very uncertain, and that there are no long-continued gaugings of the river in existence, the engineer will be inclined to put little reliance on the figures given, and we must be distinctly understood as not claiming for them any more value than they are worth. A more accurate knowledge of the climatic and other features of the region considered would doubtless lead us to alter our estimates. And finally, it is to be remarked that these figures refer to the power available with the natural fall of the stream and with its natural flow. If the water could be stored during the night, all these powers could be doubled, and the power at many shoals could doubtless be considerably increased by putting up dams.

It has not been considered worth while to calculate the theoretical available power between the principal shoals, as it is uncertain how much of it would be practically available. It is evident that the Dan river offers a large amount of available power and good facilities for manufacturing. The estimates of power, made by Swain, are as follows: (See next page.)

SUMMARY OF POWER OF THE DAN RIVER IN NORTH CAROLINA.[1]

Locality.	Distance from Clarksville.	Drainage area.	Rainfall.					Total Fall.		Horsepower available, gross.[2]		
			Spring.	Summer.	Autumn.	Winter.	Year.	Height	Length.	Minimum.	Minimum low season.	Low season, dry years.
Milton shoal	50.05	2,286	12	12	10	11	45	7.138	6,898	330	400	460
Dodsons shoal	51.61	2,270	12	12	10	11	45	2.384	1,204	......	......	......
Crowder's shoal	54.95	2,240	12	12	10	11	45	1.379	3,290	......	......	......
Rattlesnake shoal	55.78	2,230	12	12	10	11	45	1.174	3,202	......	......	......
Wilkinson's shoal	58.41	2,200	12	12	10	11	45	0.979	720	......	......	......
Pass' shoal	58.80	2,140	12	12	10	11	45	0.679	700	......	......	......
Dix's shoal	59.27	2,130	12	12	10	11	45	1.714	282	......	......	......
Noble's shoal	60.38	2,010	12	12	10	11	45	2.173	2,052	......	......	......
Devil's Jump shoal	85.86	.....	11-12	12-13	10-11	11-12	44-48	0.37	658	......	......	......
Wide Mouth shoal	87.62	.....	11-12	12-13	10-11	11-12	44-48	2.17	81	......	......	......
Indian shoal	91.21	......	11-12	12-13	10-11	11-12	44-48	0.64	890	......	......	......
Sauratown ford shoal	91.81	......	11-12	12-13	10-11	11-12	44-48	0.71	901	......	......	......
Double shoal	92.10	1,639	11-12	12-13	10-11	11-12	44-48	5.85	8,619	185	228	260
Hamblin's Island shoal	97.74	......	11-12	12-13	10-11	11-12	44-48	0.30	400	......	......	......
Galloway's fish-trap shoal	98.11	975	11-12	12-13	10-11	11-12	44-48	4.50	2,898	75	100	115
Galloway's Island	99.80	......	11-12	12-13	10-11	11-12	44-48	0.49	1,500	......	......	......
Reese's rock shoal	101.69	950	11-12	12-13	10-11	11-12	44-48	2.82	2,600	......	......	......
Eagle falls	103.65	940	11-12	12-13	10-11	11-12	44-48	3.14	1,290	......	......	......
Mulberry island shoal	107.37	......	11-12	12-13	10-11	11-12	44-48	1.38	1,250	......	......	......
Three Islands shoal	110.01	......	11-12	12-13	10-11	11-12	44-48	1.62	883	......	......	......
Lone Island shoal	110.51	......	11-12	12-13	10-11	11-12	44-48	1.93	1,450	......	......	......
Gravel bar	......	......	11-12	12-13	10-11	11-12	44-48	0.04	150	......	......	......
Slink shoal	112.57	......	11-12	12-13	10-11	11-12	44-48	2.58	1,074	......	......	......
Cross Rock rapid	112.87	......	11-12	12-13	10-11	11-12	44-48	0.69	150	......	......	......
Roberson's fish-trap	113.17	......	11-12	12-13	10-11	11-12	44-48	0.30	580	......	......	......
Gravel shoal	113.80	......	11-12	12-13	10-11	11-12	44-48	0.38	750	......	......	......
Gravel shoal	114.60	......	12	13	10	12	47	0.49	309	......	......	......
Beaver Island shoal	115.94	......	12	13	10	12	47	2.44	1,090	......	......	......
Wolf shoal	116.84	......	12	13	10	12	47	1.20	305	......	......	......
Cross Rock shoal	117.97	......	12	13	10	12	47	2.36	1,188	......	......	......
Shoal and fish dam	118.66	......	12	13	10	12	47	1.17	381	......	......	......
Sandy island shoal	119.48	560	12	13	10	12	47	3.51	3,241	31	44	50
Carter's shoal	120.79	550	12	13	10	12	47	4.70	3,276	42	60	69
Rutley's shoal	121.83	......	12	13	10	12	47	2.09	1,288	......	......	......
Buzzard Island shoal	122.67	......	12	13	10	12	47	0.52	220	......	......	......
Ladd's ford shoal	123.90	......	12	13	10	12	47	1.18	444	......	......	......
Dalton's fish-trap shoal	125.04	......	12	13	10	12	47	2.59	696	......	......	......
Granny Angel's shoal	125.71	......	12	13	10	12	47	1.33	441	......	......	......
Shoe-buckle Island shoal	126.06	......	12	13	10	12	47	2.56	1,806	......	......	......
Clay's island shoal	128.48	......	12	13	10	12	47	1.40	477	......	......	......
Fish-trap shoal	129.97	340	12	13	10	12	47	3.93	1,517	18	26	30
Hairstons falls	131.15	328	12	13	10	12	47	14.89	2,629	66	98	110
	132.76	320	12	13	10	12	47	6.65	3,280	30	44	50
Big Rock shoal	134.18	315	12	13	10	12	47	8.67	4,033	38	57	65
Mount Horrible shoal	135.53	......	12	13	10	12	47	1.85	1,119	......	......	......
Williams' fish-trap shoal	135.91	.....	12	13	10	12	47	1.79	390	......	......	......
Davis shoal	136.09	.....	12	13	10	12	47	1.01	205	......	......	......
Cow ford shoal	136.48	312	12	13	10	12	47	4.52	1,841	19	28	32
Ducking shoal	137.35	312	12	13	10	12	47	6.44	2,616	27	40	46
Fulcher's shoal	137.92	.....	12	13	10	12	47	2.01	810	......	......	......
Sink hole shoal	138.47	.....	12	13	10	12	47	1.13	1,266	......	......	......
Red shoal	138.85	275	12	13	10	12	47	4.79	2,237	18	25	29
Old mill shoal	139.47	270	12	13	10	12	47	6.22	3,317	22	32	37
Danbury shoal	141.76	250	12	13	10	12	47	10.60	.....	37	55	63
Old Iron Works shoal	......	250	12	13	10	12	47	21.00	.....	75	110	125
								29.00	.....	102	150	175

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[1] See pp. 103 and 105.

[2] See pages 54 to 59.

TRIBUTARIES OF THE DAN RIVER.

HYCO CREEK.

The first tributary of any importance above the confluence of the Dan and Staunton is Hyco creek, which enters from the south, its mouth being just above the head of Little Hyco falls. This stream rises in the extreme southern part of Caswell and Person counties, North Carolina, and flows in a northeasterly direction through Halifax county, Virginia, having a total length, in a straight line, of about 45 miles, and draining an area of about 400 square miles. It is about 125 feet wide near its mouth. Its tributaries are small and unimportant, and there are no important towns on the stream. We were unable to learn much about its power. The bed and banks are said to be everywhere favorable, the former being generally rock. The only power used on the stream is for small grist- and saw-mills, none of which are extensive. No sites not used were brought to our notice, but probably numerous ones may be obtained by damming. As the stream flows parallel to the general strike of the rock strata, it is probable that the declivity is quite uniform and not often broken by falls or rapids. In another table will be found the total amount of power utilized, compiled from the enumerator's reports.

COUNTY-LINE CREEK.

The next tributary worth mentioning is County-line creek, from the south, rising in Caswell county, North Carolina, and joining the Dan just on the state line (hence the name of the stream), after flowing in a northeasterly direction for a distance of about 25 miles in a straight line and draining an area of some 130 square miles. This stream, like the others in this neighborhood, is used only for running small saw- and grist-mills. The fall is considerable, but no great falls at any one place were spoken of, and probably do not exist, as the stream flows nearly parallel to the strike of the rocks. The declivity is probably quite uniform, and the powers obtained only by damming. We heard of no good sites unoccupied. Near the mouth of the stream is a grist and roller (flour) mill, with a dam 13 feet high, giving a fall of 11 feet. Opposite Yanceyville the stream is considerably smaller, and will only afford about 2 or 2½ horse-power per foot fall (gross) during eight months of the year. The waterpower of the stream is thus not very extensive.

MOONS AND HOGANS CREEKS.

The other tributaries below Danville—Moons creek, emptying just above Wilkinsons shoal, and draining about 57 square miles, and Hogans creek, emptying at Dix shoal, and draining about 114 square miles—are similar in character to Hyco and County-line creeks, and are utilized, like them, only to run small country grist- and saw-mills, the former with one or two run of stones. In a later table will be found the statement of the power used on these streams collectively, and more need not be said here.

The mills in this neighborhood are very little troubled by ice, and rarely have to stop on that account. The dams are generally of wood or of crib-work filled with stone, and there is no trouble in obtaining good foundations.

SMITHS RIVER.

Passing by several small creeks, one of the two important tributaries of the Dan is Smiths river, from the north, a very considerable stream. Rising in the Blue Ridge, in the northern part of Patrick county, Virginia, it flows first nearly east, and, after forming for a few miles the boundary between Patrick and Franklin counties, it enters Henry county, flows through it in a southeasterly direction, and empties into the Dan, in North Carolina, just below the town of Leaksville. The distance from its source to its mouth, in a straight line, is about 36 miles, but by the river it is probably at least twice that distance. The stream flows near to Martinsville, the county seat of Henry county, it and Leaksville being the only towns of importance on the river. The total drainage area of the stream is about 600 square miles, of which 39 are in North Carolina. The drainage area above Martinsville is 330 square miles. Not having examined the river in detail, on account of its inaccessibility, we are unable to describe its drainage basin very much in detail. From all that we could learn, however, it is well wooded, with a fertile soil which, in many places, is deep, sandy, and porous, and with facilities for artificial storage, although there are no lakes. The stream has a very rapid fall, a rock bottom almost everywhere, banks of moderate height, and few low grounds subject to overflow, although it is subject to freshets, during which the water rises 20 feet in places. It is fed to a considerable extent by constant springs, and is said not to be very variable in flow; and the extensive forests are a favorable feature in this respect.

The data regarding rainfall in the basin are very incomplete, but, according to the Smithsonian charts, it may be assumed at about 44 to 48 inches, of which 12 fall in spring, 12 in summer, 10 in autumn, and 12 in winter. There are no records of continued gaugings of the stream, or of its elevation at different points.

The stream is crossed at Spray, a few miles above its mouth, by the Leaksville and Danville Narrow Gauge railroad; Reidsville, on the Southern railroad, being 14 miles from the mouth of the river. The upper part of the river is crossed by the Roanoke and Southern railroad.

One and one-half miles above the mouth of the river, and in the town of Spray, are located the Leaksville woolen-mill, the Leaksville cotton-mill, the mill of the Spray Mercantile company and the Spray cotton-mill.

The Leaksville cotton-mill contains 400 looms, making colored cloths exclusively, and uses about 135 horsepower, developed by a turbine of 32½ inches in diameter and working under a head of 23 feet, capable of developing 180 horsepower. The mill of the Spray Mercantile company is a roller flour-mill of 50 barrels capacity per day and a corn-mill of two run of stones. The power is furnished by a turbine-wheel 25 inches in diameter and working under a head of 19 feet, and an overshot wheel working under a head of 14 feet, the two together developing about 50 horsepower. The Spray cotton-mill, containing 12,064 spindles, is driven by waterpower alone, using about 300 horsepower, developed by twin Leffel turbines of 36 inches diameter, on a horizontal shaft, and working under a head of 30 feet. The Leaksville woolen-mill is a two-set mill, using about 50 horsepower, obtained from a 25-inch "Perfection" turbine, working under a head of 19 feet.

A new mill, containing 400 looms, has been recently constructed at this place, opposite the Spray mill, and is using a 30-foot head.

These mills all draw their water from the same race, which is 16 feet wide at top, 4½ feet deep and 4200 feet long, with a bottom grade of 39 inches in this distance, and is estimated to be able to carry a quantity of water giving 600 horsepower with a head of 30 feet. The dam is 7 feet high and 600 feet long, of triangular wooden frames bolted to the bed of the river and planked over. The bulkhead is of solid rubble masonry, laid in cement, and is 12 feet wide and 13 feet high.

This dam backs the water about one-quarter of a mile up-stream, to the foot of another shoal owned by the same company as the power just described.

Plans are now being developed to build a dam on this upper shoal, where, it is claimed, a fall of 12 feet and 250 horsepower can be obtained. This power is to be transmitted, electrically, to Spray and used to run the Leaksville cotton- and woolen-mills and the corn- and flour-mill; and all the water of the river in the canal will then be used at the Spray cotton-mill and the new weaving mill under the head of 30 feet.

The river has been gauged near its mouth by H. Eaton Coleman, civil engineer, and county surveyor of Pittsylvania county, Virginia, who found the discharge to be 600 cubic feet per second "at mean low water." But as a single measurement of the flow has little value, other measurements should be made before attempting to estimate the available flow for waterpower purposes. The estimates as to the power used at the several mills given above are taken from the statements by the superintendents of the mills.

The power above this point is used only by saw- and grist-mills, in regard to which we have no detailed information. Enough was learned, however, to show that the river offers good sites for power all the way up. The river has no tributaries of much importance.

The town of Leaksville has a considerable trade in tobacco, which is the great staple of the county; but wheat and corn are also grown in considerable quantities on the fertile bottoms of the Dan, Smiths, and Mayo rivers.

Above Smiths river are several unimportant tributaries to the Dan, on some of which are small mills. They are similar in character to the other tributaries below Smiths river. On Cascade creek, a small stream entering from the north below Smiths river, Dr. J. G. Brodneax has a small saw- and grist-mill, and a very good small power, with a fall of 15 or 16 feet. Timber is very cheap in this vicinity, and wooden dams can be erected at very small cost.

THE MAYO RIVER.

The next large tributary above Smiths river is Mayo river, from the north, a stream which, like Smiths river, takes its rise on the eastern slope of the Blue Ridge, in the western part of Patrick county, Virginia, and which, after flowing in a general southeasterly direction through Patrick county and a corner of Henry county, Virginia, and Rockingham county, North Carolina, joins the Dan a little below Madison, and just above Roberson's fish-trap shoal. Its length, in a straight line, is about 55 miles, and along the general course of the stream about 60 miles, but probably considerably more if all of its windings are followed. The only town on the stream is Taylorsville, the county seat of Patrick county. Its total drainage area is about 350 square miles, of which 60 square miles are above Taylorsville, and its principal tributary is the North Mayo, from the north, draining about 90 square miles. Its drainage basin is, in all respects, similar to that of Smiths river. The fall of the stream is considerable, but it is said to be more uniform than that of either the Dan or Smiths river, and with not so many rapids and falls. The bed is rock almost everywhere, the banks high, and not many low grounds subject to overflow. In the absence of gaugings no estimates as to the possible available water will be given.

The first power on the Mayo river met with in ascending the stream is located about 1½ miles above its mouth and about 2 miles from the town of Madison. There is here a shoal which, in 2¾ miles, has a fall of 63.41 feet, divided about equally between what may be considered as two shoals. The lower of these shoals is the site of the Mayo mills, containing 23,000 mule spindles and 51 revolving top cards, manufacturing underwear and hosiery yarns, and using about 400 horsepower, obtained from water alone for the entire year, and there is said to be a large amount of surplus water.

The dam, which is located some distance below the top of this lower shoal, is a timber crib structure with stone abutments 12 feet high and 470 feet long, backing the water about one mile. The bulkhead is of brownstone, laid in cement, and is 150 feet long and 6 feet thick at the gates. The head race is 3200 feet long, with a cross-section of 190 square feet below the water surface, built partly in excavation and partly in embankment, and gives a head of 35.32 feet at the mill. The water is delivered to a pair of 30-inch McCormick turbines on a horizontal shaft, said to be capable of developing 846 horsepower under a head of 36 feet. There is also a turbine of 20 inches diameter, working under the same head as the main wheels and developing 100 horsepower, used for the lighting plant, fire pump, etc. There is said to be very little trouble from high water here.

The upper part of this shoal (or upper shoal) can be developed by building a dam above the pond of the Mayo mill, and thus another valuable power will be rendered available for operating a separate mill or the power here developed may be transmitted, electrically, to the mill already constructed.

About 2 miles further up the stream is a flour-mill, and above there are other small ones. There is very little bottom-land on the river for some six miles from its mouth, and the fall in that distance is very considerable, ledges of rock crossing the stream all the way. Above this, however, the stream is flat for 15 or 20 miles, and the facilities for power are not so good.

Above the Mayo there are several small creeks flowing into the Dan, some of which have power used, and all of which have considerable available. They are good streams for power, and, so far as we can learn, are not subject to such great variations in flow as those farther east. The powers they afford are small, but sufficient to run small grist- and saw-mills—sufficient for the needs of the people. Being easily dammed, and having considerable fall, they are preferred to the Dan river for small powers. The most important tributary above the

Mayo is Town fork, which joins the Dan just above Shoe-Buckle island shoal, but regarding it or the other tributaries above we have no detailed information.

All of these tributary creeks, as well as the Dan river itself, are subject to sudden and quite heavy freshets, but they have so much fall that, in general, not much damage is done, although on the Dan, even above Danville, there are many bottoms which are overflowed at times. The freshets are, in general, short, lasting usually, it is said, only four or five days.

Finally, it may be said of all the valley of the Dan, and particularly of the upper part, that the climate is exceedingly salubrious (much more so than in the lower part of the valley of the Roanoke river) the soil is fertile, and the people industrious and hospitable. The advantages for manufacturing are, in every respect, excellent.

ROANOKE RIVER AND TRIBUTARIES—TABLE OF POWER UTILIZED.[1]

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used. Feet.	Total horse-power used.
Roanoke river.......	Albemarle sound ...	N. Carolina.	Bertie........	Saw.............	1	......	30
	Do......	.....do......	Northampton	Flour and grist	2	16	76
	Do......	.....do......	Halifax	Grist mill	1	45	250
	Do......	.....do......	.....do........	Grain elevator.	1	45	
	Do......	.....do......	.....do........	Cotton-seed oil.	2	45	
	Do......	Virginia ...	Mecklenburg	Flour and grist	2	11¼	41
	Do......	.....do......	.....do........	Saw.............	2	11¼	41
Tributaries of........	Roanoke river	N. Carolina.	Washington .	Flour and grist	2	18	22
	Do......	.....do......	Bertie........	......do.........	4	34¼	67
	Do......	.....do......	.....do........	Saw.............	2	16	35
	Do......	.....do......	Martin........	......do.........	2	19	42
	Do......	.....do......	.....do........	Flour and grist	3	29	40
	Do......	.....do......	Northampton	......do.........	3	29	32
	Do......	.....do......	Warren........	......do.........	7	111	178
	Do......	.....do......	.....do........	Saw.............	4	54	82
	Do......	.....do......	Granville	Flour and grist	13	178½	163
	Do......	.....do......	.....do........	Tobacco........	1	10	8
	Do......	.....do......	.....do........	Saw.............	4	59¼	62
	Do......	Virginia ...	Mecklenburg	......do.........	8	110	171
	Do......	.....do......	.....do........	Flour and grist	17	260	331
	Do......	.....do......	.....do........	Cotton-gin	1	31	16
Dan river.............	Do......	.....do......	Halifax.......	Flour and grist	8	21	60
	Do......	.....do......	Pittsylvania .	......do.........	2	25	65
	Do......	.....do......	.....do........	Saw and plan'g.	1	7	50
	Do......	.....do......	.....do........	Foundry and machine shop	2	17	70
	Do......	N. Carolina.	Stokes........	Flour and grist	2	25	38
Hyco river............	Dan river .	.....do......	Person	......do.........	2	26	34
	Do......	.....do......	.....do........	Saw.............	2	26	26
	Do......	.....do......	Caswell.......	Flour and grist	3	41	44
	Do......	Virginia....	Halifax	......do...	2	18	35
	Do......	.....do......	.....do........	Saw.............	1	8	20
Bannister river......	Do......	.....do......	Pittsylvania .	Flour and grist	2	24	40
	Do......	.....do......	Halifax	......do.........	3	45	148
	Do......	.....do......	.....do........	Saw.............	1	10	20
	Do......	.....do......	.....do........	Tobacco........	1	10	18
Smiths river..........	Do......	N. Carolina.	Rockingham.	Cotton factory.	1	30	300
	Do......	.....do......	.....do........	......do.........	1	23	135
	Do......	.....do......	.....do........	Woolen factory	1	36	50?
	Do......	.....do......	.....do........	Flour and grist	1	19	50
	Do......	.....do......	.....do........	Saw.............	1	12	20
	Do......	.....do......	.....do........	Millwrighting..	1	28	35
	Do......	Virginia....	Henry........	Flour and grist	2	20	60
	Do......	.....do......	.....do........	Saw.............	3	46	83
	Do	.....do......	Patrick.......	Flour and grist	1	13	20
Mayo river...........	Do......	N. Carolina.	Rockingham.	......do.........	1	20	20
	Do......	.....do......	.....do........	Cotton mill.....	1	25	..
	Do......	Virginia....	Patrick.......	......do.........	1	15	16
Other tributaries of.	Do......	N. Carolina.	Granville	......do.........	3	46	40
	Do......	.....do......	.....do........	Saw.............	2	33	30
	Do......	.....do......	Person.	Saw.............	4	..	65
	Do......	.....do......	.....do........	Flour and grist	6	80	92
	Do......	.....do......	Caswell	......do.........	14	176	218
	Do......	.....do......	.....do........	Saw.............	8	82	126
	Do......	.....do......	.....do........	Agricultural implements..	2	32	30
	Do......	.....do......	Rockingham.	Flour and grist	12	169½	203
	Do......	.....do......	.....do........	Saw.............	9	120+	145
	Do......	.....do......	.....do........	Blacksmithing .	1	10	6
	Do......	.....do......	Stokes.......	Flour and grist	18	264	285
	Do......	.....do......	.....do........	Saw.............	7	96¼	130
	Do......	Virginia....	Halifax.......	Flour and grist	19	344	354
	Do......	.....do......	.....do........	Saw.............	11	243	194
	Do......	.....do......	.....do........	Foundry........	1	8	8
	Do......	.....do......	.....do........	Agricultural implements ..	3	37	24

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[1] Mainly from 10th census returns.

ROANOKE RIVER AND TRIBUTARIES—TABLE OF POWER UTILIZED.[1]—*Continued.*

Name of stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
						Feet.	
	Dan river	Virginia	Pittsylvania	Flour and grist	18	307	412
	Do	do	do	Saw	4	77	70
	Do	do	Henry	Flour and grist	19	331	241
	Do	do	do	Saw	6	142	121
	Do	do	do	Agricultural implements	1	17	30
	Do	do	do	Leather	1	16	6
	Do	do	Patrick	Flour and grist	1	15	15
Staunton	Roanoke	do	Halifax	do	1	6	12
	Do	do	do	Saw	1	14	15
	Do	do	Charlotte	Flour and grist	1	10	25
	Do	do	Campbell	do	8	14½	135
	Do	do	Bedford	do	2	18	20
	Do	do	do	Saw	1	3	7
	Do	do	Pittsylvania	do	1	14	12
	Do	do	Roanoke	do	1	10	16
	Do	do	do	Flour and grist	8	30	60
	Do	do	Montgomery	do	2	25	45
	Do	do	do	Saw	1	..	20
	Do	do	do	Furniture	1	10	6
Little Roanoke	Staunton	do	Charlotte	Flour and grist	2	10	32
	Do	do	do	Saw	1	7	18
Falling creek	Do	do	Campbell	Foundry	1	10	20
	Do	do	do	Flour and grist	3	35	79
	Do	do	Appomattox	do	1	12	23
	Do	do	do	Saw	1	12	25
Otter river	Do	do	Bedford	Flour and grist	3	44	43
	Do	do	do	Saw	3	45	35
	Do	do	do	Woolen	1	..	..
	Do	do	Campbell	Flour and grist	1	2	25
Goose river	Do	do	Bedford	do	6	77	93
	Do	do	do	Saw	4	58	32
Pig river	Do	do	Franklin	Flour and grist	4	..	62
	Do	do	do	Saw	1	16	25
Blackwater river	Do	do	do	Flour and grist	2	28	22
	Do	do	do	Saw	1	9	20
Other tributaries of.	Do	do	Halifax	Flour and grist	6	86	111
	Do	do	Charlotte	do	10	199	223
	Do	do	do	Saw	2	41	36
	Do	do	Campbell	Flour and grist	8	105½	238
	Do	do	do	Saw	2	26½	60
	Do	do	Bedford	Flour and grist	15	229	253
	Do	do	do	Saw	10	151	136
	Do	do	Pittsylvania	Flour and grist	1	18	12
	Do	do	do	Saw	2	26	36
	Do	do	Franklin	do	5	80	50
	Do	do	do	Flour and grist	21	310	307
	Do	do	do	Wheelwright'g	1	15	4
	Do	do	Roanoke	Flour and grist	12	176	252
	Do	do	do	Saw	8	100	105
	Do	do	do	Foundry	1	7	4
	Do	do	do	Fertilizers	1	22	15
	Do	do	Montgomery	Flour and grist	2	21	23

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[1] Mainly from 10th census returns.

CHAPTER VI.

THE TAR AND NEUSE RIVERS AND TRIBUTARIES.[1]

THE TAR RIVER.

This river takes its rise in Person and Granville counties, North Carolina, flows in a southeasterly direction through Franklin, Nash, Edgecombe, and Pitt counties, and empties into the Pamlico river, in Beaufort, near the town of Washington, its length, in a straight line, being about 120 miles, and by the river perhaps 175. The principal towns on the stream are Washington, Greenville, Tarboro, Rocky Mount, and Louisburg. Tarboro, 53 miles from Pamlico river, is the head of navigation, and it is hoped to secure ultimately a channel 3 feet in depth at all stages of the water up to this point, but at present this depth exists only during nine months of the year. The obstructions to navigation consist of stumps, snags, fallen trees, and artificial obstructions placed there during the war.

The river drains an area of about 3000 square miles, the greater part of which lies north of the stream, from which side the principal tributaries—Swift and Fishing creeks—enter, draining, respectively, 350 and 760 square miles. The stream crosses the fall line at Rocky Mount, below which point there is no waterpower. The general character of the drainage basin resembles that of the Roanoke. The leading productions are tobacco, corn, and cotton, most of the cotton being raised in the eastern part, and most of the tobacco in the western. There are no lakes in the basin. The bed of the stream above the fall line is rock in places, but generally sand, clay, gravel or mud, the declivity of the stream being quite uniform. Above Rocky Mount the bottoms are narrower than on the Roanoke, and the banks are generally high enough to confine the river, except in very heavy freshets. Below Rocky Mount the banks are often overflowed, the river rising sometimes 25 feet at Tarboro.

The average annual rainfall on the basin of the Tar is about 50 inches, but above the fall line it is less—about 46 or 48 inches, distributed nearly as follows: spring, 12; summer, 14; autumn, 10; winter, 11. For gaugings on this river, see pages 294 to 297.

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[1] By G. F. Swain and J. A. Holmes.

The fall of the stream below Rocky Mount is said not to exceed 1 or 1½ feet per mile, making the total fall below that point between 50 and 75 feet. The elevation of the stream at the crossing of the Raleigh and Gaston railroad is 188 feet, making the fall between that point and the head of the fall at Rocky Mount about 2 feet to the mile or less, the distance being in the neighborhood of 60 miles.

WATERPOWER ON TAR RIVER.

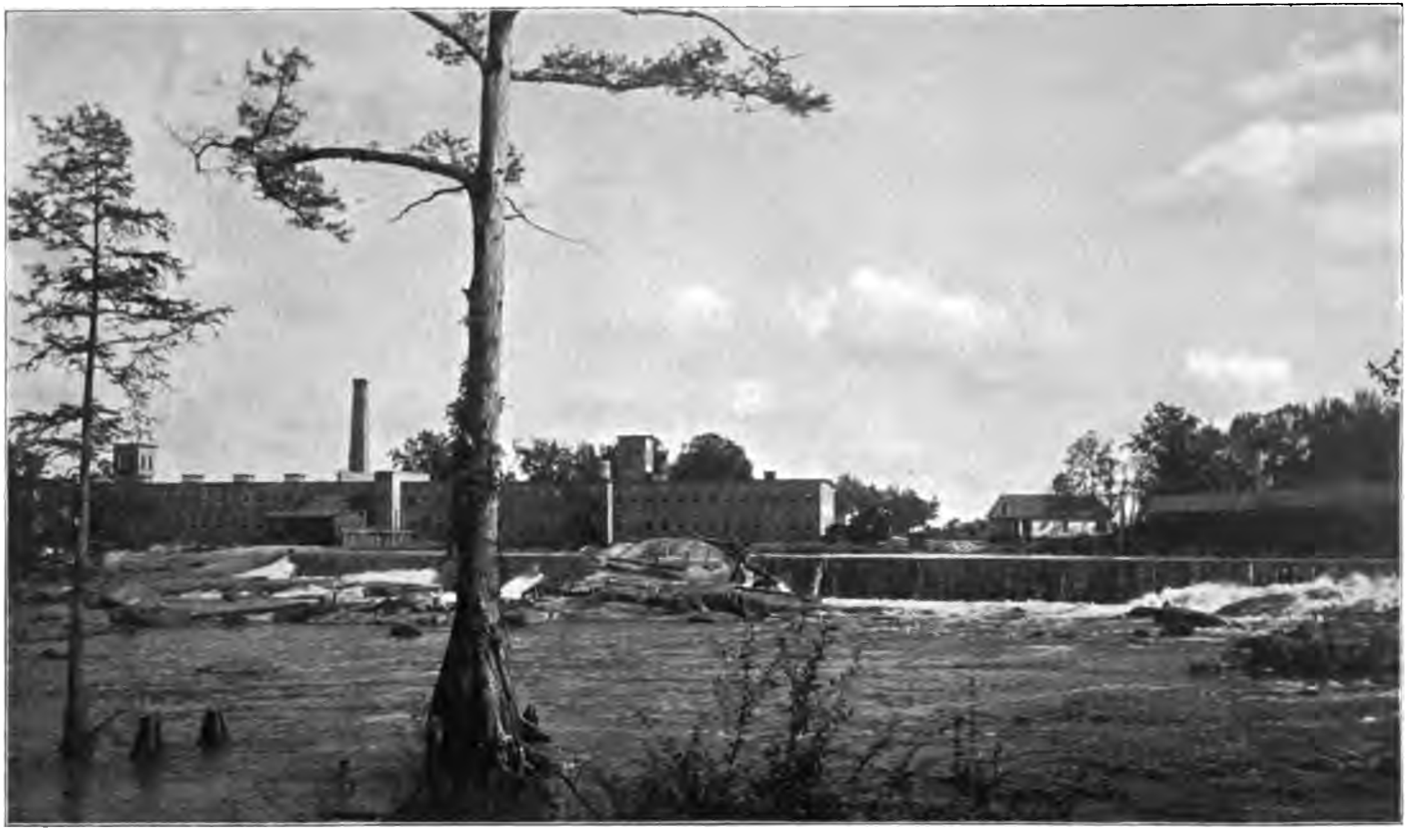
Ascending the stream the waterpowers met with are as follows:

Rocky Mount Mills.—The first power met with is the site of the Rocky Mount mills, situated at the fall line in the town of Rocky Mount and on the Atlantic Coast Line railroad. The dam extends entirely across the stream in a slightly broken line, with an excellent rock foundation. It is built of granite, 600 feet long and averages 11 feet high. The bed of the river is of solid rock and the banks moderately high, affording a safe development. The race is 191 feet long and the fall at the turbine-wheels is 24 feet. The mills are three in number, and contain 25,000 spindles, using, it is said, about 1000 horsepower, developed during nine months of the year by water alone; during the other three months the auxiliary steam plant is called into service to supply the deficiency. It is said that this power is capable of still further development by raising the dam and by deepening the tail race. (See Plate IV.)

The drainage area above this place is about 768 square miles, and the mean annual rainfall about 47 inches, already stated. Daily gaugings on the river at Tarboro have been made since July 25, 1896 (see p. 294), but these have not yet been continued over a long enough time to permit of waterpower estimates being made. The total available fall may be taken as 24 feet.

Above Rocky Mount the river is sluggish for some distance, after which the fall becomes considerably greater. On the upper part of the river there are only saw- and grist-mills, and there are no sites of importance not used, although on the upper part of the stream, and on its tributaries, there are many places where power could be obtained by damming.

Between Rocky Mount and Louisburg there are two small grist-mills and gins; the lower one a small mill with 8 feet fall, the dam being 215 feet long and 6 feet high, built of wood, at a cost of $600, and throwing the water back 1½ miles; and the uper one, that of Mr. N. R. Strickland, a saw- and grist-mill, with a dam of wood and stone 180 feet long, 7 feet high, and costing $1000, and backing the water 7 miles,



COTTON MILLS AND WATERPOWER DEVELOPMENT AT ROCKY MOUNT

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with an average width of 150 feet. At this mill a fall of 7 feet is used, and about 50 horsepower, net, with a waste of water all the time, except in times of extreme drought.

At Louisburg Col. J. F. Jones has a saw- and grist-mill, flour-mill and cotton-gin using 8 feet fall and running full capacity all the time, with water wasting. The dam is of rock, 180 feet long and 9 feet high, throwing the water back 2 miles, with an average width of 150 feet; a power of about 65 or 75 horsepower is said to be used.

Above this there are no mills of importance. It will be seen that the waterpower of the Tar river, other than that at Rocky Mount, does not amount to much, being almost all obtained by damming, and there being no natural fall of any consequence except that at Rocky Mount.

TAR RIVER—SUMMARY OF POWER.

Locality.	Distance from Tarboro.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross.[1]			Utilized.	
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum, low season.	Low season, dry years.	Horsepower, net.	Fall.
	Miles	Sq. ms.	In.	In.	In.	In.	In.	Feet.	Feet.					Feet.
Rocky Mount mills..	20±	768	12	14	10	11	47	24	2,800	336	408	461	1000[2]	24.00
Vivaratti's mill......	34±	615						8	......	80	100	115	....	8.00
Strickland's mill.....	46±	565						7	......	66	85	97	50	7.00
Louisburg............	75±	383						8	......	45	60	69	60	8.00

TRIBUTARIES OF THE TAR RIVER.

FISHING CREEK.

This creek is the first important tributary of Tar river met with in ascending the stream. It rises in Warren county, forms for some distance the boundary line between Halifax, on the north, and Nash and Edgecombe on the south, and empties into the Tar in the latter county. Its length, measured in a straight line, is about 50 miles, and its drainage area 760 square miles. Its only tributary worth mentioning is Little Fishing creek, which enters from the north. The stream crosses the fall line near Enfield, and the general character of its drainage basin is the same as that of the Tar river. The waterpower of the stream is not extensive, and is used for saw- and grist-mills, cotton-gins, and one cotton-factory.

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[1] See pages 54 to 59. Also pp. 294-297.

[2] During 9 months of the year.

The first power is that of Dr. J. T. Bellamy, at the fall line, 4 miles from Enfield, where there are a saw- and grist-mill, gin, and cotton-yarn mill, the last named of which has not been operated for several years owing to the antiquated character of the machinery and the lack of capital for more modern equipment. The dam is of stone, built in 1857, at a cost of $9000, and is 168 feet long and 12 feet high, backing the water about 3 miles, and overflowing some 200 acres of swamp land to an average depth of perhaps 7 or 8 feet. At one end of the dam is the cotton-factory, and at the other the saw- and grist-mills, all using a fall of 12 feet and a total of about 50 horsepower, of which the factory formerly used perhaps 30, with a turbine-wheel, and it is said with always a waste of water. The drainage area above this place being about 500 square miles, and the rainfall 47 inches, the available power is estimated to be at least 60 horsepower in the low season of dry years, 70 in the low season of ordinary years, and twice that amount, or more, during nine months—these powers being gross, but doubtless capable of being increased to a very large extent by drawing down the water in the pond during working hours. This site is 4 miles from the railroad.

The next power is that of William Burnett, 6 miles west of the railroad, at Millbrook. The dam in 1880 was wood (crib-work), filled with stone, 260 feet long and 8 feet high, backing the water about three-fourths of a mile, but not throwing it out of its banks. A race 60 feet long lead to the mill—a grist- and saw-mill—where a fall of 5 feet (?) was used. The amount of water in the stream here is probably about the same as at Bellamy's. If the available fall is 8 feet, the available power is therefore about two-thirds of that at the latter place. The bed of the river here is rock, and very favorable for a dam.

The remaining powers on this creek and its tributaries are not worthy of special mention. They are included in the table below. The grist-mills generally have one, two, or three run of stones.

On the whole, as far as could be ascertained, the stream is not of much value for waterpower, on account of its small fall and its variable flow. We heard of no good sites not used, but there are probably places where a certain amount of power could be obtained by damming.

SWIFT CREEK.

Swift creek rises in the southeast portion of Vance county, where it is called Sandy creek; flows through Franklin, Nash, and Edgecombe, joining the Tar about 7 miles above the mouth of Fishing creek, its length, in a straight line, being about 50 miles, and draining an area of about 350 square miles. In general character it is similar to Fishing creek, but is said to be more sluggish, and to have lower banks.

Its waterpower is not valuable, and we heard of no sites not occupied. The power utilized will be found in the table. The mills are saw- and grist-mills, cotton-gins, and one cotton-yarn factory, at Laurel, belonging to Col. J. F. Jones. The latter is the most important of the utilized powers. The dam is of wood and stone, 50 feet long, 5 feet high, backing the water one mile, and giving a fall of 12 feet, with a race 60 feet long. The power is used for a grist- and saw-mill, and for a cotton-yarn factory, with 650 spindles, using perhaps, in all, 40 or 50 horsepower.

The remaining tributaries to the Tar river are of no importance, and the only mills on them are small saw-mills and grist-mills with one or two run of stones. The smaller streams nearly dry up in summer, and many of the mills have to stop grinding. The table for the utilized power of the Tar and its tributaries is compiled from the returns of the enumerators:

TABLE OF POWER UTILIZED ON TAR RIVER AND ITS TRIBUTARIES—PRINCIPALLY FROM CENSUS OF 1880.

Stream.	Tributary to what.	State.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
						Feet.	
Tar river	Pamlico river	N. Carolina.	Nash	Cotton factory.	1	24	1000[1]
Do	do	do	do	Flour and grist.	3	29½	85
Do	do	do	do	Saw	1	12	30
Do	do	do	do	Cotton-gin	3	27	22
Do	do	do	Franklin	Flour and grist.	1	9	40
Do	do	do	do	Saw	1	9	25
Do	do	do	Granville	Flour and grist.	6	90	153
Do	do	do	do	Saw	5	65	98
Fishing creek	Tar river	do	Halifax	Cotton factory[2]	1	12	30
Do	do	do	do	Flour and grist.	2	19	40
Do	do	do	do	Saw	2	19	40
Do	do	do	Warren	Flour and grist.	7	100	148
Swift creek	do	do	Edgecombe	do	1	7	30
Do	do	do	Nash	do	2	19	35
Do	do	do	Franklin	do	3	30	53
Do	do	do	do	Saw	1	12	15
Do	do	do	do	Cotton factory.	1	12	20
Do	do	do	Warren	Flour and grist.	6	90	211
Other tributaries of	do	do	Pitt	do	4	29	74
Do	do	do	do	Saw	2	14	84
Do	do	do	Edgecombe	Flour and grist.	3	35	75
Do	do	do	do	Saw	2		49
Do	do	do	Halifax	Flour and grist.	4	62	67
Do	do	do	Nash	do	4	27	96
Do	do	do	do	Saw	1	8	12
Do	do	do	do	Agricultural implements.	1	8	12
Do	do	do	do	Cotton-gin	1	7	4
Do	do	do	Franklin	Flour and grist.	14	234	251
Do	do	do	do	Saw	9	135	163
Do	do	do	do	Cotton-gin	2	22	18
Do	do	do	do	Leather	1	15	10
Do	do	do	Warren	Flour and grist.	5	106	112
Do	do	do	do	Saw	1	15	20
Do	do	do	Granville	Flour and grist.	11	133	186
Do	do	do	do	Saw	6	91	108

[1] Said to be used during nine months of the year.

[2] Not now operated.

THE NEUSE RIVER AND TRIBUTARIES.

DRAINAGE AREAS.	Square miles.
Neuse river, at mouth	5,299
Neuse river, at New Bern	4,250
Neuse river, at Goldsboro	2,451
Neuse river, at Smithfield	1,317
Neuse river, at Milburny	995
Neuse river, at paper-mill	890
Contentnea creek, at mouth	991
Little river, at mouth	326
Little river, at Lowell	195
Flat river, at mouth	166
Little river, at mouth	130
Eno river, at mouth	134

The Neuse river is formed in the northwest corner of Wake county, North Carolina, by the union of three small streams, the Eno, Flat, and Little rivers, which themselves take their rise in Person and Orange counties. The Neuse flows in a general southeasterly direction through Wake, Johnston, Wayne, Lenoir, and Craven counties, emptying into Pamlico sound below New Bern, its general course, in its lower and navigable portion, being more nearly east. It forms for a short distance the boundary between Granville and Durham counties, and, near its mouth, between Pitt and Pamlico on its left and lower Craven on its right. Its length above New Bern, measured in a straight line, is about 150 miles, but it is much greater following the river, which is very tortuous in places. The principal towns on the stream are New Bern, Kinston, Goldsboro, Smithfield, and Hillsboro, the last being on the Eno. The head of navigation on the river is Smithfield, about 160 miles above New Bern, and the government has, at intervals, been engaged in improving the river up to this point. At present there is a navigable depth of 3 feet as far as Goldsboro (97½ miles above New Bern) during eight or nine months of the year.

The area drained by the Neuse comprises about 5300 square miles. That part above New Bern measures about 4250 square miles. The principal tributaries of the river enter from the north, viz. the Contentnea creek (mouth about 30 miles above New Bern) and Little river (mouth just above Goldsboro, 97½ miles above New Bern), draining, respectively, about 990 and 325 square miles, approximately. The river crosses the fall line near Smithfield, and below that point there is no waterpower. The fall at Smithfield, however, is not very great, and the fall line is less prominent than in the case of the Roanoke and the Tar, the ledge of rock, forming the falls at Weldon and Rocky Mount, showing itself only very slightly on the Neuse.

Below Goldsboro the river flows through a low, heavily-timbered country, and is very like the Roanoke in general character. The soil is alluvial—clay, sand, and marl; the banks from 3 to 20 feet high; the country covered with extensive pine forests and cypress swamps, and the staple product cotton. Some of the bottoms have been reclaimed by the use of dikes. Below Contentnea creek the banks and adjacent bottoms are only a few inches above low water, and the floods reach a height of 12 feet, covering large areas. The channel is very tortuous, cut-offs are often formed, and the navigation difficult. Above Smithfield the drainage basin presents no peculiarities that have not been referred to in speaking of the Roanoke and Tar. The map will show its form and dimensions. In the upper part of the valley a fine quality of granite is quarried, and in the lower part, not far above New Berne, a marl is found which is said to be a very good building-stone, being quite soft when quarried, but becoming very hard on exposure. In fact, there is no lack of building material in the valleys of the Neuse, Tar, or Roanoke.

As regards bed, banks, and freshets, the river is similar to the Roanoke, except that the bottoms are said to be less extensive (above Smithfield) and the freshets not so sudden nor violent, seldom endangering dams. Trouble with ice is very rare. There are no lakes or artificial reservoirs, but there are facilities for the latter on the upper tributaries.

The rainfall is 49.8 inches—12.18 in spring, 13.99 in summer, 11.35 in autumn, and 12.28 in winter, approximately. For gaugings on this river see pages 297 to 300.

The fall of the river below Smithfield is very small, its elevation at that point being in the neighborhood of 106 feet. At the crossing of the Raleigh and Gaston railroad, some 35 miles further up, the elevation is about 175 feet, making the fall between these points at the rate of 2 feet to the mile. Professor Kerr states that the total fall, from the northwest corner of Wake county, about 32 miles above the railroad crossing, to tide, is about 340 feet; it seems, however, scarcely probable that the fall in these 32 miles can be at the rate of 5.3 feet to the mile.

WATERPOWER ON NEUSE RIVER.

The first site for power in ascending the river is at Smithfield, where are to be found the lowest rapids, and it is said that there was once a mill there, although it is now gone. Although some power might be obtained at the place, the site is not a favorable one. The river at Smithfield is 130 feet wide, and the natural fall is but slight.

Milburny.—The next site, and the first one of importance, is at Milburny or Neuse mills, about 25 miles above Smithfield and 6 or 7 miles from Raleigh, formerly improved, but at present idle. There is an open frame dam across the river, 8 feet high and 250 feet long, built on the site of the old dam which was constructed years ago in connection with the old paper-mill. The fall is 11½ feet at the site of the old mill, developing about 300 horsepower at mean low water. At the present time this power is not utilized except for running a dilapidated grist-mill, which requires about 15 horsepower. It is evident that the natural fall here is not very pronounced, and it seems strange that there is no large fall on the river below this point. It is probable, moreover, that power might be got below by damming, but it is said that there are no favorable places where a dam could be built without trouble by overflowing land above. At Milburny the bed is solid rock, very favorable for a dam, and the race had to be blasted out. The banks are abrupt on the right, but not so much so on the left, and the location is said to be a safe one. The power was formerly used by a paper-mill on the left bank and a grist- and saw-mill on the other, the fall utilized being 12½ feet; but the paper-mill was burnt. It is expected, however, that the power will be again utilized in a short time.

The drainage area above this site is about 1000 square miles. Professor Kerr gauged the river at low water, and found the flow to be about 193 cubic feet per second, giving a power of 22 horsepower per foot fall. Gaugings at Selma in 1897 by the Geological Survey gave a flow as low as 109 cubic feet per second. The drainage area here is given as 1175 square miles. The water, at the time of this gauging, stood higher than it did at some other times during the year. Estimates of the flow and power, according to methods already referred to, result as follows:

TABLE OF POWER AT MILBURNY.[1]

State of flow.	Drainage area.	Fall.	Flow, per second.	Horse-power, gross.	Horse-power, gross.
(See pages 54 to 59).	Sq. Miles.	Feet.	Cubic feet.	Per foot fall.	Per 12½ feet fall.
Minimum	1,000	12½	160	18.2	227
Minimum, low season			175	20.0	250
Low season, dry years			190	21.8	272
"Low water," Professor Kerr			193	22.0	275

By storing the water during the night this power could be greatly increased, but whether such storage would be practicable we cannot say, not knowing the dimensions of the pond.

This power, as before remarked, is about 6 miles from Raleigh, from which point railroads diverge in four directions.

FALLS OF NEUSE.—The next power on the river is the paper-mill of the Raleigh Paper Company. Between this power and Milburny there was formerly an oil-mill, but the dam is said to have caused so much trouble by overflow, and so much sickness in the vicinity, that the property was purchased by the neighbors, and the mill torn down. The paper-mill is at Falls of Neuse, 3 miles above the Raleigh and Gaston railroad, and 13 miles north of Raleigh. The open frame dam, which extends entirely across the river, is about 410 feet long and 6 feet high, backing the water about 10 miles, the depth averaging perhaps 8 feet. A race 1000 feet long leads to the mill, where there is a fall of 18 feet. The power used is said to be 300 horsepower, but it is evident that this power can only be obtained during eight or nine months of the year. There is little trouble with high water. The dam was repaired a few years ago, but there is still some loss of power from leakage.

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[1] For recent measurements of flow on Neuse river, see pp. 297-300.

The drainage area above this place is about 890 square miles, and the rainfall 42 to 44 inches. Hence the power, available, per foot, would be about eight-tenths of that at Milburny, or, in round numbers, as given in the following table:

TABLE OF POWER AT FALLS OF NEUSE.[1]

State of flow.[2]	Drainage area.	Fall.	Flow, per second.	Horsepower.	Horsepower.
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	Per foot fall.	Per 18 feet fall.
Minimum	890	18	128	14.5	261
Minimum, low season			140	15.9	286
Low season, dry years			152	17.2	309

Above this mill there are no powers of importance on the river so far as we could learn. It seems strange that such a large and long river should offer so little power, especially in a section of country which abounds so largely in waterpower. The fact that there is no power on the fall line is also remarkable.

The following table gives a summary of the powers on the river utilized and available:

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[1] According to all we could learn regarding this power, we are inclined to regard these estimates as too large, being informed that it is sometimes only possible to run a grist-mill in summer for several weeks at a time. But the dam is very leaky, and it may be that there are other sources of loss.

[2] For measurements of flow on Neuse river, see pp. 297-300.

NEUSE RIVER—SUMMARY OF POWER.

Locality.	Distance from head of navigation.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross.[1]			Total utilized.	
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum, low season.	Low season, dry years.	Fall.	Horsepower, net.
	Miles	Sq.m.	In.	In.	In.	In.	In.	Feet.	Miles				Feet.	
Milburny	25	1,000	11	13	10	10	44	12½	......	227	250	272	0	0
Falls of Neuse	38	890						18	......	261	286	309	18	300[2]

TRIBUTARIES OF THE NEUSE RIVER.

Most of the utilized power in the drainage basin of the Neuse is located on its tributaries, although none of them are large enough to afford very large powers.

The first important one met with in ascending the Neuse is the Trent river, which joins the Neuse at New Bern. The drainage basin of the Trent, lying entirely below the fall line and presenting no waterpower of importance, need not be further considered.

CONTENTNEA CREEK.

The next important tributary is Contentnea creek, from the north, draining an area of about 990 square miles, and joining the Neuse about 30 miles above New Bern. This stream has its sources above the fall line, in Franklin county, where it is called Moccasin creek; thence, flowing in a southeasterly direction, it forms the boundary line between Franklin and Nash counties on the north and Wake and Johnston on the south, flows through Wilson and Greene counties, and finally joins the Neuse, after forming for 6 or 7 miles the boundary between Pitt and Lenoir counties. It crosses the fall line, in Wilson county, about at the point where it changes its name to Contentnea; but, as in the case of the Neuse, there seems to be no decided fall in the stream at this point. Above the fall line it partakes of the general character of Swift and Fishing creeks, previously described, and it affords no waterpower of much importance, the declivity being gradual. There is probably power available on the stream which can be utilized by damming at suitable places, but no particular sites for powers were brought to our notice. The tributaries of the Contentnea are not of much importance.

LITTLE RIVER.

The next important tributary is Little river, which rises in Franklin, flows southeast through Wake and Johnston, joining the Neuse in

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[1] See pages 54 to 59.

[2] See statement in text above.

Wayne county 2 or 3 miles above Goldsboro, and draining an area of about 325 square miles, the length of the stream, in a straight line, being nearly 60 miles. The drainage basin is long and narrow, and the tributaries of no consequence. The stream crosses the fall line, but, as in the case of the Neuse, no particular fall occurs at that place. The products of the basin are principally corn, cotton, cereals, vegetables, and fruits, and the soil fertile, generally sandy and loamy. The general character of the stream does not differ from that of the tributaries of the Tar. The banks are often low and subject to overflow, and the bed is generally of soft material—mud, sand, etc. The declivity is quite uniform, and no important sites for power could be learned of.

At Lowell, about where the stream may be said to cross the fall line, and some 25 miles from its mouth, stood the cotton-factory owned by William Egerton till 1892. This was burned in January, 1894, and on its site has since been erected a corn- and flour-mill. The power is developed by a wooden dam 170 feet long and 9 feet high, giving a fall of about 9 feet. It backs the water 4 miles, with an average width of 150 feet and an average depth of 6 feet; and the number of horsepower is about 40, which, it was said, could be obtained at all seasons of the year. The drainage area above the place being about 195 square miles, and the rainfall about 48 inches, we have estimated the minimum and the low-season flow in dry years at about 12 and 18 cubic feet per second, respectively, and the available power, with a fall of 10 feet, at 13 and 20 horsepower. With storage during the night these figures could be increased, and this may easily be done if the pond is as large as given above. Above the Lowell mills, on Little river, are only small saw- and grist-mills. The waterpower of the stream may be said to be, in general, of little value.

In the neighborhood of Goldsboro there are several small spring streams which are said to afford quite constant powers, but none of them have sufficient capacity to run any but very small mills. Such are Sleepy creek (mouth 10 miles below Goldsboro) and Falling creek (mouth 10 miles above the railroad bridge). On these streams large storage can generally be obtained, and the power resulting from the natural flow could be doubled by being concentrated into twelve hours.

The other tributaries of the Neuse below the junction of its three headwaters have numerous small grist- and saw-mills and occasionally a paper-mill, all of which are here tabulated. Most of these mills have to stop during the dryest seasons of the summer on account of low water.

Flat river, the most northerly of the three headwater streams referred to, rises in Person county and flows southeast through a corner of Durham, having a total length of some 25 miles in a straight line. It drains an area of about 166 square miles, being the largest of the three streams, has a considerable fall, and is well suited for the development of small powers. The power utilized is given in the table. The power available we cannot estimate. One of the best powers in this vicinity is reported to be at and just below the corn- and flour-mill of Mr. E. R. Moore in Person county and near the Durham county line.

Little river is the second of the three headwaters. Rising in Orange county, with perhaps a few branches in Person, and flowing a little south of east through the northern part of Orange, with a total length, in a straight line, of some 20 miles, it drains an area of about 130 square miles. None of these streams are very tortuous. Little river has the same general character as Flat river, and its power is utilized by saw- and grist-mills, and by one cotton-factory, that of the Willard Manufacturing Company. This factory contains 80 looms and 1600 spindles, operated from two-thirds to three-fourths of the year by water-power alone, the stream furnishing about 60 horsepower for 12 hours; and during the remainder of the year it is operated by water and steam combined. The dam is 21 feet high and 125 feet long, backing the water about one-half mile. This gives a fall of 22 feet at the end of a race 1200 feet long. In summer there is no waste of water, but in winter it generally flows over the dam. The flow of this stream at its mouth is estimated to be at a minimum about 5, and at its low-season flow, in dry years, 18 cubic feet per second, giving powers of 12 and 44 horsepower, with fall of 22 feet.

Eno River.—The most southerly of the three headwaters of the Neuse is the Eno, rising in the northwest corner of Orange county, flowing first nearly south and then nearly east through the county, having a length of about 25 miles in a straight line, and draining an area of about 134 square miles. It is similar in character to the others, and its power is used only by grist- and saw-mills, some of which are obliged to stop in the summer. At Hillsboro the stream is about 50 feet wide, and will probably afford not more than 8 or 9 cubic feet per second in dry years during the low season, and probably less, or about 1 horsepower per foot fall. The utilized power is given in the table.

It will be seen that the Neuse river possesses a small amount of water-power for a stream of its size in this part of the country. The lower parts of the river and the tributaries below the Raleigh and Gaston railroad are not very favorable for power—the river on account of its gradual fall and low banks, and the tributaries because of the considerable variability in their flow. Exceptions are found in the case of some tributaries not far below the fall line, which are fed by springs and keep up quite well during the summer, belonging, in fact, to the class of sand-hill streams, of which we shall meet more noticeable examples in the case of the tributaries to the Cape Fear and Yadkin. The tributaries in the upper part are more favorable, have a greater fall, higher banks, and are probably not so variable in their flow. Still, there are no such sites for power on the Neuse river as are found on the Roanoke, Tar, or on streams farther south.

NEUSE RIVER AND TRIBUTARIES—TABLE OF POWER UTILIZED.[1]

Name of stream.	Tributary to what.	State.	County.	Kind of Mill.	No. of mills.	Total fall used.	Total horse-power used, net.
						Ft.	
Neuse river	Pamlico sound	N. Carolina.	Wake	Paper	1	18	300[2]
Do	do	do	do	Flour and grist.	1	10	20
Do	do	do	do	do	1	8	20
Contentnea cr'k (Moccasin)	Neuse river	do	Wilson	do	8	23	79
Do	do	do	do	Saw	2	16	60
Do	do	do	do	Cotton-gin	1	6	8
Do	do	do	Johnston	Flour and grist.	2	17	107
Do	do	do	do	Saw	1	12	70
All tributaries to	Contentnea c'k	do	Greene	Flour and grist.	6	63	145
Do	do	do	Wilson	do	6	48	100
Do	do	do	do	Saw	2	16	45
Do	do	do	do	Cotton-gin	8	32	48
Do	do	do	Wayne	Flour and grist.	2	17	12
Do	do	do	do	Saw	1	8	18
Do	do	do	Nash	Flour and grist.	2	....	22
Do	do	do	do	Saw	2	....	22
Little river	Neuse river	do	Johnston	Flour and grist.	2	14	77
Do	do	do	do	Saw	2	16	40
Do	do	do	do	Grist mill	1	9	40
Do	do	do	Wake	Saw	1	14	16
All other tributaries to	do	do	Wayne	Flour and grist.	4	50	120
Do	do	do	do	Saw	1	10	10
Do	do	do	do	Woolen	2	....	....
Do	do	do	Johnston	Agric'lt'l imp'ts	1	8	20
Do	do	do	do	Flour and grist.	13	183	206
Do	do	do	do	Saw	8	89	86
Do	do	do	Pamlico	Flour and grist.	1	8	20
Do	do	do	Jones	do	3	89	70
Do	do	do	Craven	do	1	8	4
Do	do	do	do	Cotton-gin	1	....	....
Do	do	do	Lenoir	Flour and grist.	8	27	86
Do	do	do	Wake	do	23	309	397
Do	do	do	do	Saw	8	120	133
Do	do	do	do	Woolen	1	....	15
Do	do	do	Franklin	Flour and grist.	1	20	15
Do	do	do	Granville	do	8	49	72
Do	do	do	do	Saw	1	18	30
Flat river and tributaries.	do	do	Orange	Flour and grist.	4	50	100
Do	do	do	do	Saw	1	12	20
Do	do	do	Person	do	5	61	145
Do	do	do	do	do	5	....	125
Little river and tributaries	do	do	Orange	do	4	55	48
Do	do	do	do	do	6	86	90
Do	do	do	do	Box	1	....	6
Do	do	do	do	Cotton-factory.	1	22	60
Eno river and tributaries.	do	do	do	Flour and grist.	18	271	358
Do	do	do	do	Saw	4	60	55

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[1] Compiled mainly from returns of 10th census.

[2] See p. 123.

CHAPTER VII.

THE CAPE FEAR RIVER AND TRIBUTARIES.[1]

THE CAPE FEAR RIVER.

This river, formed by the junction of the Haw and Deep rivers in Chatham county, North Carolina, flows in a southeasterly direction through Harnett, Cumberland, Bladen, and Brunswick counties, and for a short distance between Brunswick and New Hanover, and empties into the Atlantic at Cape Fear. Its length, in a straight line, is about 125 miles, and by the river about 192. The principal towns on the stream are Wilmington, 30 miles from the mouth; Elizabethtòn, the county-seat of Bladen county; Fayetteville, the county-seat of Cumberland county; Averasboro, and Lillington (the county-seat of Harnett county)—the two latter being small towns of a few hundred inhabitants. Fayetteville is the head of navigation for steamers of light draft, its distance from the sea being 160 miles by the course of the stream. Considerable money has been, and is being, spent by the government for the improvement of the navigation of the river below Wilmington, which is a port of entry, and present project contemplates the securing of a navigable depth of 20 feet at mean low water up to that city; but by taking proper advantage of the tides ships drawing 21 feet can easily reach that point. The average range of the tides at Southport, at the mouth of the river, is about 4 feet. The entrance across the bar to the harbor at Southport can be made by vessels drawing 25 feet at spring tides.

By a series of locks and dams the river was formerly made navigable up to the confluence of the Haw and Deep rivers, and the works were carried for some distance up the Deep river. These old navigation works, like those on the Roanoke, were never successful from a financial point of view, and before long went into disuse, and were abandoned. Between 1872 and 1874, however, a part of the works were again put in order, and navigation again opened between Battles dam and Carbonton, and kept open for several years successfully. But at present they have again passed into disuse, and are practically abandoned so far as navigation is concerned.[1]

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[1] By G. F. Swain and J. A. Holmes.

The total area drained by the Cape Fear is about 8400 square miles, of which the Deep river drains 1350, the Haw river 1675, and the Cape Fear proper 5375. The principal tributaries of the river below the forks are: From the east, in order as the river is ascended, the Northeast Cape Fear river, draining 1330 square miles, and entering the Cape Fear about 20 miles above its mouth; the South river, draining about 1430 square miles, and joining the main stream about 30 miles from its mouth; and from the west, in the same order, Rockfish creek, draining 280 square miles, and emptying 10 miles below Fayetteville; Lower Little river, draining 448 square miles, and emptying about 25 miles above Fayetteville; and Upper Little river, draining about 176 square miles, and emptying about 30 miles above Fayetteville.

The drainage basin of the Cape Fear proper, without the basins of the Deep and Haw, resembles that of the Roanoke. The river is crossed by the fall line near Averasboro, about 27 or 28 miles above Fayetteville, giving rise to Smileys falls, which is yet to be described. The map of the basin will show its form and general dimensions. The elevations of the watersheds between the Cape Fear and the adjacent rivers are not very great, and the tributaries do not afford much power, except in places where, by damming, the water can be thrown back for considerable distances and considerable storage room obtained; but the fall of the tributaries is, on the whole, small. As regards soil, vegetation, and building material, the drainage basin of the Cape Fear resembles that of the Roanoke, and need not be described. The facilities for storage in that part below the junction of the Haw and Deep rivers will probably be found to be not very good on account of the flatness of the country, and, in places, of the porosity of the soil—resembling in this respect, also, the Roanoke. Further up, in the valleys of Deep and Haw rivers, the storage facilities are better. As regards bed, banks, and freshets, the stream very closely resembles the Roanoke, although the bottoms are said to be not quite so extensive as on the latter river. Above Averasboro the river flows through an alluvial country, with banks generally low, and a width of from 400 to 600 feet. Below Averasboro the river is narrow, the banks high, and the soil sandy.

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[1] The Cape Fear Navigation Company was first chartered by the state in 1796, with a capital of $80,000. In 1815 additional privileges were granted, and authority given to increase the capital stock to $100,000. Although the money was expended, no useful result was accomplished, and in 1848-49 a new company was organized, with a capital of $200,000, which was afterward increased to $350,000, the state subscribing three-fifths of the whole amount. Surveys were made, but the cost of the works which were entered upon exceeded the estimates, and although a steamer did once pass over the whole route between Fayetteville and Carbonton, on Deep river, the company was never able to keep the locks and dams in a condition requisite to secure uninterrupted communication. The failure of these works was partly due to bad engineering in the location of the dams, it being difficult to secure their ends against the action of freshets. The amount expended by the last company was about $350,000. (Annual Report Chief of Engineers, 1873, pp. 743-4.) The work was finally abandoned when the war broke out, and subsequently the works were in a measure destroyed, in part by natural causes, and in part intentionally. In 1868 the state appropriated the works to the Raleigh and Augusta Air Line railroad (then Chatham railroad), but they were afterward bought by some parties who organized as the Deep River Manufacturing Company. A little later, the Lobdell Car-wheel Company having bought an interest in the company, and also the Endor furnace, the works were again put in order from Battles dam up, in the years 1872 to 1874, for the purpose of supplying the Endor furnaces with the Buckhorn ore, for which there was no convenient transportation except by water. Navigation was kept open for several years successfully, although the company has carried on no traffic since 1876. In that year the Deep River Manufacturing Company was consolidated with the Cape Fear Iron and Steel Company, under the new name of "The American Iron and Steel Company," but the furnaces were stopped, owing to the depression in the iron business, and this, of course, put an end to the navigation, which was confined to that carried on by the company, no local trade having been built up, the single steamboat owned by the company being no more than sufficient for their own wants. Subsequent to 1876 the boat was run whenever a paying trip could be made, but not regularly, and no trips have been made since 1880. The boat has disappeared, and with it all expectation of navigation on the river. It is now the intention of the owners of the locks and other old works at Lockville and other places to develop waterpowers wherever possible.

The rainfall on the basin of the Cape Fear is about 50 inches—12 in spring, 14 in summer, 12 in autumn, and 12 in winter; but in the valleys of the Deep and Haw rivers, although the total rainfall remains the same, the summer fall is rather smaller, and that in winter remains about the same. It would seem to follow from these facts that the flow of the Cape Fear becomes proportionately more variable as it is ascended. Another cause which tends to make the flow of the river variable is the fact that the courses of many of its tributaries in Chatham county lie in a slaty and broken region, which sheds the water with great rapidity, so that these streams become almost dry in summer; and this cause also contributes to increase the suddenness and violence of the freshets. The freshets on the Cape Fear, indeed, are said to be more violent than on any other North Carolina river. On the lower part of Deep river the banks are often overflowed, sometimes to a depth of 10 or 12 feet, and much injury is thereby done to the crops. For the upper 30 miles of the Cape Fear the banks are low and the river wide, so that the rise does not exceed 20 feet; but in the succeeding 75 miles, where the banks are high and the stream narrow, the rise is very great, amounting occasionally to 58 feet at Fayetteville. These freshets constitute a serious disadvantage to the use of waterpower on the stream. There is, however, no trouble at all with ice. Gaugings are now being made daily on the Cape Fear at Fayetteville, and on Deep and Haw rivers just above their junction (pp. 301 to 305).

The following table shows the declivity of the stream:

CAPE FEAR RIVER—TABLE OF DECLIVITY.

Locality.	Distance from Wilmington.	Elevation above tide.	Distances between points.	Fall between points.	Average fall between points.
	Miles.	Feet.	Miles.	Feet.	Ft. per mile.
Junction of Haw and Deep rivers[1]	172.0	130	29.5	61	2.060
Head of Smileys falls	142.5	69	3.5	27	7.710
Foot of Smileys falls	139.0	42	27.0	35	1.250
Fayetteville	112.0	7 (?)	112.0	7	0.062 (?)
Wilmington	0.0	0			

The principal products of the region along the Cape Fear are corn, cotton, peanuts, potatoes, pease, rice, various vegetables and fruits, rye, oats, wheat, and grasses. The whole of this region lies in the cotton-belt.

The mineral resources of this region, especially of the upper part, are very great. Coal and iron are very abundant, but, owing to difficulties of transportation, the mines have been little worked. The coal-fields along the Deep river have been estimated by Emmons to cover an area of 90 square miles, and to contain at least 258,000,000 tons, easily workable. The coal is bituminous, and of superior quality. At Cumnock,[2] on Deep river, a shaft was excavated to a depth of 460 feet between 1853 and 1856, but operations were suspended on account of want of transportation. In 1887 the shaft was cleaned out and the mine reopened. Since that time mining operations have been continued to the present date. Iron has been found at Ore Hill, about 9 miles from the Gulf, and at Buckhorn, on the east bank of the Cape Fear, 8 miles below the forks; and all the way up through the valleys of the Haw and Deep rivers iron ore of excellent quality has been found in large quantities. Copper ore has also been found in the same region, and several mines have been worked.

The basin of the Cape Fear is not very thickly populated, and its population has not increased much since 1870. In that year the population per square mile was 22.7, while in 1880 it was only 28.4. (Census Bulletin No. 78, by Mr. Gannett, geographer of the Census.) At the same rate of increase the population would now (1897) be 35.9 per square mile.

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[1] At crossing of Raleigh & Augusta Air Line railroad. This and the other elevations on the road were furnished by Major Winder, then general superintendent.

[2] Formerly known as Egypt.

WATERPOWER ON THE CAPE FEAR.

We proceed to describe the river more in detail and to discuss its waterpowers, commencing at its mouth.

Below Wilmington there is, of course, no power. The country is low and flat, and large quantities of rice are raised. The river is, in places, over a mile wide, and at the mouth the width is 3 miles. The country is also more or less swampy for 50 miles above Wilmington; there is no power for this distance, and rice, corn and cotton are the principal products. Thence up to Fayetteville the banks are from 15 to 50 feet high, the bed entirely sand, and the navigation difficult, on account of shifting sand-bars.

The first dam of the old Navigation Company was at Jones falls, 7.73 miles above Fayetteville, its height having been about 5 feet. It is not a good site for power.

The second dam was at Silver run, 17.11 miles above Fayetteville, its height having been probably greater, as its crest was 15.64 feet above that of the Jones falls dam. It was not spoken of as a good site for power.

The third dam was at Williams fish-trap, 25 miles from Fayetteville. The total fall from the top of the dam to low water at Fayetteville was 25.74 feet. Not a good site.

The fourth dam was at Haw Ridge, 27 miles above Fayetteville; height of crest above Fayetteville (low water), 34.97 feet. Not a good site. None of the dams thus far mentioned are now in existence.

SMILEYS FALLS.—Up to this point the fall of the river is slight, and its general character similar to what it is for some distance below Fayetteville. We now come to the fall line, where the river passes from the middle to the eastern division over a long shoal known as Smileys falls. In the table of declivity we have already stated that the fall extends through a length of about 3½ miles, with a total fall of about 27 feet. There were three dams built on these falls, viz. Green Rock, Big Island (Narrow Gap), and Sharpfield, the latter being at the head of the falls, and all of which have been completely carried away. The table following, on page 137, will show their distances from Fayetteville, and the height of their crests above the datum. "At Narrow Gap a ledge of rocks from 4 to 6 feet above the ordinary bed extends nearly across the river, leaving a narrow opening near the left bank, whence comes the name. The whole volume of water, during ordinary stages, passes through this gap."[1] Smileys falls, really the first power on the river, none of those below being worth anything as powers, are situated above the mouth of Upper Little river, and about 4 miles from the railroad. The bed is rock, and the facilities for dams and races, as well as for building, are said to be good. The greatest drawback would probably be the heavy freshets to which the river is subject, and which have been already referred to; but the fall is so great at this place that it seems as though this difficulty might be, to a large extent, obviated, if it were not endeavored to utilize the total available fall at low water. There is no power at present in use at the place, or if there is, it is only for some small country grist-mill; but none such was heard of.

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[1] Quoted from a report on a survey of the Cape Fear and Deep rivers, by Mr. George H. Elliot, Annual Report Chief of Engineers, 1872, p. 742.

The drainage area above this place being about 3400 square miles, the power is estimated in the following table:

TABLE OF POWER AVAILABLE AT SMILEYS FALLS (ESTIMATED).[1]

State of flow.	Drainage area.	Rainfall.					Flow per second.	Horsepower available, gross.		Horsepower utilized.
		Spring.	Summer.	Autumn.	Winter.	Year.				
(See pages 54 to 59.)	Sqr. miles.	In.	In.	In.	In.	In.	Cubic feet.	1 foot fall.	27 foot fall.	
Minimum................	3,400	12	13	10	11	46	620	70.0	1,890	0
Minimum, low season..							820	92.7	2,500	0
Low season, dry years..							930	106.0	2,860	0

For the same reason a concentration of power into less than twenty-four hours would probably be impracticable, except to a very small extent.

This power, one of the finest in this section of the state, is located in a region offering many advantages for manufacturing. Fuel, in the shape of timber and coal, is abundant in the immediate neighborhood. Building materials—fine wood and stone—are also to be had with ease. The products of the neighborhood are corn, cotton, wheat, oats, rye, pease, potatoes, vegetables, and fruits of various kinds. In case of the establishment of a cotton-factory, an abundance of the raw material could probably be obtained from the surrounding country; and a branch road could be easily built to this place from Dunn station on the Atlantic Coast Line railroad only 4 miles distant. Finally, this part of the state is quite healthy, although not so much so as the western portion, chills and fever being more prevalent.

The next dam above Sharpfield dam was McAllisters, 3 miles above, the present fall in the river between these points being about 8 feet.

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[1] For later measurements of flow of Cape Fear river, see pp. 302-305.

Then came Fox Island dam, 3 miles above, the natural fall being now 10 feet. The next was Douglas falls dam, rather over 8 miles above, and the fall is 9 feet. The bed of the river above Smileys falls is rock, and the fall considerably greater than below.

BATTLES FALLS.—The next dam above Douglas falls was at Battles falls, where is the first dam at present existing on the river, having been, as already mentioned, the lowest dam rebuilt by the last company (p. 128). But even of this dam only the remnants remain. The fall between Battles dam and Douglas falls, a distance of a little over 3 miles, is 9 feet. Battles dam was a wooden structure, straight across the river, and about 11 feet high and 500 feet long. This fall might be used for power, as the place is topographically favorable, but the freshets would be a drawback to the use of so small a fall. The dam originally ponded the water for 2 miles, up to the foot of Buckhorn falls. It is expected that this power will be developed at an early date.

BUCKHORN FALLS.—This is the most important fall on the river next to Smileys, navigation through which was effected by means of a canal. At the head of the falls are the remnants of a dam, built of wood, like Battles dam, and about 1000 feet long and 3 or 4 feet high. It has the shape of a letter V, with the apex up-stream, one arm being nearly at right angles to the banks, and it is terminated on the east side by an island, behind which it turns a portion of the water, as into a natural race, which extends for a distance of a mile or so between the bank and a succession of islands, which have been connected by a series of slough-dams. At the end of the mile a slough-dam connected the last of the series of islands with the bank, and the navigation was continued by means of a canal about half a mile long, 40 feet wide at the surface, and 6 feet deep. At its head was a guard-lock, with a lift of about 4 feet, and at its foot two locks, made of crib-work filled with stone, like the guard-lock, with together 17 feet lift, one having 11 and the other 6 feet, making the total fall from the crest of the Buckhorn dam to that of Battles dam some 22 or 23 feet. A part of the fall was used by the North Carolina Iron and Steel Works to run machinery connected with their furnaces (blast, etc.), the canal having been extended some 300 yards from a point just above the outlet-locks, so as to utilize the power lower down, nearer the ore-bed. A fall of 12 feet was used, the water being discharged into a small creek having a fall of some 5 feet between the tail-race and the river. Although in freshets the backwater from the river came up to the wheel-pit, full capacity could be secured during the whole year, and no steam-power was used. These works have not been in operation since 1876, it being said that the ore-bed is exhausted, not being so extensive as was supposed, although it is not certain that this is the case.

These falls constitute a most excellent power, very easily available, and with a location perfectly safe. The existing canal constitutes a race ready for use, and by utilizing the lift of the guard-lock and discharging the water directly into the river at the works a fall of 20 feet could be rendered available, except during very severe freshets, when the works might be obliged to stop, although this would be *very* rare. The canal is in tolerably good condition, and could be made perfect at a small cost; and, if necessary, it could be easily widened so as to increase its capacity. At its lower end, where the locks are, the land is low for several hundred yards back from the river, and subject to overflow at times; but further back is a hill, on which buildings could be erected with safety, and on which stands the old furnace of the iron company.

We have estimated the available power and flow at this point, with the results given in the following table:

TABLE OF AVAILABLE POWER AT BUCKHORN FALLS (ESTIMATED).

State of flow.	Drainage area.	Rainfall.					Flow per second.	Horsepower available, gross.		Horsepower utilized.
		Spring.	Summer.	Autumn.	Winter.	Year.				
(See pages 54 to 59.)	Sq. miles.	In.	In.	In.	In.	In.	Cu. ft.	1 ft. fall.	20 ft. fall.	
Minimum	3,200	12	13	10	11	46	575	65.4	1.300	0
Minimum, low season							765	87.0	1,740	0
Low season, dry years							875	100.0	2,000	0

The present canal, or one 40 feet wide at top, 6 feet deep, and slopes of 45°, would be capable of carrying volumes of water, and of affording power, with different slopes, as per the following table:

TABLE OF POWER AFFORDED BY CANAL IN EARTH, 40 FEET WIDE, 6 FEET DEEP, SIDES AT 45°, AT BUCKHORN FALLS.

Fall of canal.	Capacity per second.	Horsepower available, gross.		Remarks.
	Cubic feet.	1 foot fall.	Total.	
1 foot per mile	450	51	1,020	Available fall about 20 feet.
2 feet per mile	625	71	1,349	Available fall about 19 feet.
3 feet per mile	790	90	1,620	Available fall about 18 feet.

The estimates of flow in the first table, and in that for Smileys falls, may seem too low, but the flow of the Cape Fear was stated to be very variable. Gaugings at Fayetteville, in 1897, as given on page 302, show that the quantity discharged was in one case as low as 424 cubic feet per second, or 0.1 cubic feet per second per square mile, and this was not the minimum stage even in that year. The theoretically available power, with storage, would be found impracticable, although the power due to the ordinary flow of the stream might be considerably increased by constructing storage reservoirs in the valleys of Deep and Haw rivers.

Buckhorn falls are fairly accessible, being only about 8 miles from Haywood, at the junction of Haw and Deep rivers, and from the Seaboard Air Line railroad, which crosses both rivers near their junction. With a dam at Buckhorn, shallow boats could be operated between this point and the railroad crossing, 8 miles above; and the construction of a branch track to the falls from the main Seaboard Air Line railroad just east of the Haw river crossing would entail but little expense for grading over the entire distance of 7 or 8 miles. As already mentioned, coal and building materials can be obtained in abundance in the vicinity. The locality is healthy, and the climate mild. The property, including land, canals, and dams, has all been owned by the Navigation Company, but it has recently (March, 1899) been sold to a newly organized electric power company, and is to be developed as a waterpower in connection with the power at Lockville.

The width of the Cape Fear at Buckhorn dam is about 700 or 800 feet, and the dam ponds the water with this average width up to the forks, and beyond, or about 8 miles. Buckhorn falls is thus the highest power on the river.

In the following table of power on the Cape Fear river we have only mentioned those powers which may be considered as available practically, viz. Smileys falls, Battles falls, and Buckhorn falls.

It will be noticed that there is not one mill in operation on the river, probably because small mills—the only kinds that have ever sought a location in this part of the state—have been more cheaply located on small streams, where there is not such danger from heavy freshets.

CAPE FEAR RIVER—SUMMARY OF POWER (ESTIMATED).

Locality.	Distance from Fayetteville.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross[1]			Total utilized.		Per cent. of minimum utilized.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum, low season.	Low season, dry years.	Fall.	Horsepower, net.	
	Miles	Sq.m.	In.	In.	In.	In.	In.	Ft.	Miles				Ft.		
Smileys falls	30.5	3,400	12	13	10	11	46	27	3.5	1,890	2,500	2,880	0	0	0
Battles falls	48.0	3,200	12	13	10	11	46	11	0.0	720	950	1,100	0	0	0
Buckhorn falls.......	51.0	3,200	12	13	10	11	46	20[2]	1.5	1,800	1,740	2,000	0	0	0

[1] See pages 54 to 59.

[2] See description.

TABLE GIVING NUMBER AND LOCATION OF DAMS CONSTRUCTED ON THE CAPE FEAR AND DEEP RIVERS BY THE NAVIGATION COMPANY, TOGETHER WITH A PROFILE OF THE RIVERS BETWEEN FAYETTEVILLE AND HANCOCKS DAM.

[Taken from a map and profile of the rivers according to a survey by Hamilton Fulton, civil engineer, in the office of the State Geologist in Raleigh.]

Name of dam or place.	Distance from Fayetteville bridge.	Elevation of crest or water surface above low water at Fayetteville.
	Miles.	Feet.
Fayetteville bridge	0.00	0.00
Jones falls dam	7.73	50.00
Silver Run dam	17.11	20.64
Williams fish-trap dam	25.00	25.74
Haw Ridge dam	26.99	34.97
Green Rock dam	28.14	45.47
Big Island dam (Narrow Gap?)	29.37	53.61
Sharpfield dam	30.59	62.56
McAllisters dam	33.65	73.18
Fox Island dam	36.50	80.46
Douglas dam	44.76	88.68
Battles falls	47.97	99.51
Buckhorn falls	50.00	108.47
Buckhorn dam	51.65	122.39
Deep river, near junction with Haw	60.44	127.11
Lockville dam (lower)	......	151.67
Lockville dam (upper)	62.21	165.02
Gorgas dam (Cleggs)	64.70	172.24
Endor dam (Farishs fish-trap)	71.43	174.36
Gulf dam (Haughtons)	81.37	181.66
Carbonton dam (Evans)	87.37	190.12
Tysers dam (Hancocks)	99.87	204.64

NOTES ON THIS TABLE.—The height of each dam may be found approximately (a little too large) by subtracting from the height of its crest that of the dam below, except in cases where locks and canals were used, *i. e.* in the case of the Buckhorn dam, the lower Lockville dam, and the Gorgas dam.

These figures, having reference to the work as originally planned, are not correct for those now in existence, for in some cases these figures were altered when the works were built, and in others they have been altered since.

TRIBUTARIES OF THE CAPE FEAR BELOW THE FORKS.

The first important tributary of the Cape Fear, as we ascend the river, is the *Northeast Cape Fear*, which rises in the extreme northern part of Duplin county and flows south, through Pender and New Hanover counties, entering the Cape Fear river at Wilmington, some 20 miles from the sea. Lying entirely below the fall line, it has no water-power of any consequence, flowing mostly through swamps. There are only a few small mills on the stream and its tributaries, the fall of water in each case depending upon the height of dam.

The next important tributary is *South river*, also from the east, rising, under the name of Black river, in the northeastern part of Harnett county, and flowing south through that county, and between Cumberland, Bladen, and Brunswick counties on its right, and Sampson and Pender on its left, entering the Cape Fear about 10 miles above Wilmington, after a course, in a straight line, of about 85 or 90 miles. Its drainage area comprises about 1430 square miles. Although its sources are above the fall line, the stream is very small where it enters the eastern division, and its waterpower is, therefore, of no consequence. Some of the small tributaries near its sources have, as in the case of the Northeastern Cape Fear, small grist-mills, but of no consequence. The South river has one large tributary, the *Black river* (not the one above mentioned), which enters from the east, after having flowed, from north to south, through the whole length of Sampson county, in the northern part of which its sources lie. Its length is about 50 miles in a straight line, and its drainage area 620 square miles; but as it lies entirely in the eastern division, it possesses no waterpower. There are no towns of importance on these streams. They are so swampy that the towns are located some miles from them on higher and more healthy ground.

COLLY CREEK.

Another tributary of the Black river is Colly creek, on which, a few miles above its mouth and just over the county line in Bladen county, is a waterpower of some local importance now owned by the Colly Veneer Works Company. The fall is 9½ feet, and it can be increased to 12 feet. The dam backs the water four or five miles, the pond being ¼ to ⅜ of a mile broad. The present plant consists of two grist-mills, saw-mill and basket and veneer machinery, but only a small part of the water is said to be used. The surplus water escapes over a spillway 198 feet wide, on which it is said to stand, at a depth of 1 to 1½ feet all the time. Plans have been under consideration for utilizing this power for generating electricity for lighting the city of Wilmington, 20 miles distant. The stream is fed by numerous large swampy areas, and there is but little variation in the summer and winter water supply.

ROCKFISH CREEK.

We next come to Rockfish creek, which rises in the western part of Cumberland county, flows nearly east, forming for about 10 miles the boundary between Cumberland and Robeson counties, and empties into the Cape Fear about 10 miles below Fayetteville, in the former county. Its length, in a straight line, is about 30 miles; following the general course of the stream it is about 35 miles, but taking in all its windings it is considerably more. It drains, in all, an area of 280 square miles, and its principal tributaries are from the north, the largest being the Little Rockfish, draining an area of 77 square miles. There are no towns on the stream.

Rockfish creek is a good sample of a class of streams which we have not yet described in detail, not having had occasion to refer to any particular powers on any of them, although some tributaries of the Neuse and Tar belong to this class. These streams, located generally just below the fall line, which they sometimes cross, differ very materially in character from the majority of streams in this part of the country. We have alluded to the fact that just below the fall line there is a belt of sand-hills, some 30 or 40 miles wide, running almost parallel with that line, and sometimes extending above it. The streams of the class referred to rise and flow through this sandy region, and it is to this fact that their character is due. The sand-hill belt consists of broad, flattish swells, well wooded, as a rule, with long-leaf pine, and generally with an undergrowth. The surface deposit of sand varies generally from a foot or two to five or six feet in depth, and is in places 10, 20, and even 100 feet thick. It is underlaid with less porous strata of half-compacted sand, grit and clay of the tertiary and cretaceous formations, which are in places very thick, having been bored into to a depth of 175 feet at one place. The smaller streams in the sand-hills have not cut out their beds through the sand, and are often sluggish, stagnant, and marshy; but the larger creeks, and the rivers, have cut away the sand entirely and worn out their beds in the less pervious strata beneath, which sheds into the water-courses all the water which reaches it by percolation.

The rapidity with which the sand-hills absorb the rain which falls upon them, thus removing it from the direct action of the sun, has the effect of diminishing the evaporation, while their large thickness in places enables them to absorb considerable water, and to give it out gradually, as it reaches and flows along the impervious stratum beneath, thus enabling them to act as storage reservoirs, and to regulate the flow to a remarkable degree. Thus there is considerable difference in the sand-hill streams, according to the depth of the sand on their drainage basins, and by no means are all these streams good sources of power. Sand and gravel in general, although they absorb water rapidly, give it out rapidly also, unless occurring in sufficient masses to be able to store up considerable water without becoming saturated. Hence the depth of the sand-hills acts very beneficially, and when the sand is deep the streams of the class referred to not only discharge a large proportion of the rainfall on their drainage basins, but discharge it very uniformly, their flow being remarkably constant. The power which can be obtained from these small streams is sometimes remarkable, as we shall see further on in a study of Hitchcocks creek in Richmond county. Their value is also increased by the fact that the topography of the sand-hill region is such that large ponds can be obtained easily, and storage-room sufficient, not only to regulate the flow to a considerable extent during the year, but also to permit of the concentration of the entire flow of the stream into working hours, thus rendering it possible to double the power due to the natural flow if the mills are only worked 12 hours. Those streams which have cut deep channels for themselves through the sand down to and into the impervious stratum of hard pan flow considerably below the general surface of the country, often 50 or 60 feet. The banks of the Big Rockfish, for example, are almost 100 feet high near the Cape Fear, and well wooded. These sand-hill streams are, of course, not subject to such heavy freshets as ordinary streams. Big Rockfish has been known to rise 14 feet, but 10 feet is a very large rise, while Little Rockfish rises only 6 or 7 feet. There is, however, not much land overflowed. The smaller streams, however, are sometimes bordered by wet grounds, heavily wooded and overgrown, nearer the general surface of the ground, and lying high above the beds of the main streams. Though the sand-hills are, as a rule, well wooded, the woods have in parts been cut down to a considerable extent, and it is stated, and doubtless truly, that the flow of the streams in these sections is more variable than formerly.

Judging from observations made on the sand-hill streams tributary to the Cape Fear, Yadkin, Catawba and Savannah, it would seem a fair allowance if we assume them to discharge at their minimum about 0.5 cubic foot per second per square mile; at their low-season flow 0.65, and at their ordinary flow 0.75 to 1 cubic foot per second per square mile of drainage basin.

Regarding available power on these streams it was difficult to obtain much information, owing to the fact that the streams have a uniform declivity, with no falls, so that power may, as a rule, be obtained at almost any point where the banks are favorable for the location of a dam and buildings.

The drainage basin of Rockfish creek lies below the fall line; and the stream has no falls, but a gradual declivity. The map shows the general form and position of the basin. Like the others of this class, it has no lakes, but the facilities for constructing reservoirs are tolerably good. The banks are moderately high, and seldom overflowed; the rise in freshets is small, the flow very constant and strong, and the fall rapid. The rainfall is about 50 inches, 12 in spring, 14 in summer, 12 in autumn, and 12 in winter—a distribution which, of itself, would tend to render the flow constant. Of the available power on this stream but a small proportion is being utilized. Formerly there were one or two saw-mills located on it below the mouth of Little Rockfish creek, but these have all disappeared. Above this point there is one cotton-mill (Hope mill No. 2), a few small saw- and grist-mills, and several promising but undeveloped waterpowers.

At HOPE MILL No. 2, located on the north side of the stream but a short distance above the mouth of Little Rockfish creek, there is a wooden dam 18 feet high, giving a fall of 18 feet and backing the water for a distance of two miles. The mill contains 210 looms and 10,000 spindles, which are operated entirely by waterpower, about 200 horsepower being utilized, and the supply of water is ample during even the dryest years.

LITTLE ROCKFISH CREEK.

Little Rockfish creek, a tributary of Rockfish creek, is the same in general character as the main stream, which it enters about 7 miles, in a straight line, from the Cape Fear. The first power on this stream is an unimproved site formerly occupied by Murphy's paper-mill, with 18 feet fall, and an available power, at all seasons, of at least 100 horsepower net (with good wheels), judging by the power used at the other mills on the stream. This power is one-fourth of a mile from the mouth of the stream, with no important tributaries below it. The drainage area above is therefore about 77 square miles.

On Little Rockfish creek, about 1½ miles above its mouth, is the HOPE COTTON-MILL No. 1, a cotton-mill, with grist- and saw-mill attached, using a power of about 175 horsepower, with a fall of 22 feet. The dam is of wood, 53 feet long and 22 feet high, rebuilt in 1872 at a cost of about $2000, and ponding the water over about 200 acres to a depth of 7 feet. A race 300 feet long leads to the wheel. No steam is used for power, and by storing the water during the night full capacity may be obtained at all seasons, the factory being run during 12 hours. The present cotton-mills contain 192 looms and 5600 spindles. Mr. Oakman, the former president of this mill, carefully measured the water used by his wheels, and stated it to be 89.7 cubic feet per second, saving the water at night; *i. e.* the natural flow of the stream is never less than 44.5 cubic feet per second. The drainage area above the mill being about 70 square miles, the stream discharges at its minimum 0.63 cubic feet per second per square mile—a remarkable discharge.

Two miles above Hope mill No. 1 is the BLUFF COTTON-MILL (H. W. Lilly), a cotton-factory, containing 3100 spindles and 64 looms, with a fall of 9 feet, using 60 horsepower. The dam is earth, 900 feet long, 18 feet high, built in 1872, and costing $5000, and the pond covers 75 acres to an average depth of 8 feet. Full capacity can be secured the whole year. The drainage area above being about 55 square miles, the discharge of the stream should be very nearly 0.63 cubic foot per second per square mile to give the power stated if the water is stored at night.

On *Beaver creek*, 1¼ miles above Bluff mill, there is another water-power now utilized in running the CUMBERLAND COTTON-MILL, which contains 88 looms and 3200 spindles. There is here a dam 500 yards long and 14 feet high, giving a head of 16 feet at the mill and said to develop 189 horsepower under a full head during the entire year. A calculation, on these data, gives the discharge of the stream so great that we are inclined to think that some of the figures must be erroneous. In fact, the amount of machinery run in the mill is not much greater than in the Bluff mill.

Above the Bluff mill the Little Rockfish and its tributaries are well utilized by a number of small saw- and grist-mills.

Above the Rockfish there are a number of smaller streams belonging to the same class which flow into the Cape Fear, two of which empty almost in the town of Fayetteville, and on which there were four factories before the war, but the powers are small—not over 20 or 30 horsepower, probably, during dry seasons. There are some small grist-mills on all these streams, generally running two pair of stones.

On *Blounts creek*, in the town of Fayetteville, there is a water-power that runs the Fayetteville cotton-mill, containing 3120 spindles and operated by water supplemented by steam-power. The dam is 340 feet long and gives a fall of 19 feet. About 85 horsepower is required to operate the machinery of the mill, of which it is estimated that one-half is furnished by the water.

Carvers creek is a small tributary about 7 miles above Fayetteville, which, a short distance from its mouth, falls over a ledge of hard pan and soft rock a distance of 18 or 20 feet, but in dry weather the supply of water in the stream is much reduced. It operates King's saw- and grist-mill.

Lower Little river, which rises in Moore county and flows east through Cumberland, and between Cumberland and Harnett, emptying into the Cape Fear below Averasboro, is the next important stream above Rockfish. Its length is 45 miles in a straight line, and its drainage area about 448 square miles. The principal town on the stream is Manchester, a very small place. This stream, with its tributaries, may be classed among the sand-hill streams, but its basin lies near the upper limit of the sand-hill belt, and so the general character of the sand-hill streams (like the Rockfish) is not so pronounced here, the flow being not quite so constant and the freshets rather more violent, the water rising some 15 feet. The banks are high and well wooded, and the bed of the stream the same as has been described; the country, as a whole, is not so sandy. The fall of the stream is uniform, and at the rate of 3½ feet per mile.[1] The flow is estimated as follows:

TABLE OF ESTIMATED POWER ON LOWER LITTLE RIVER.

Place.	Drainage area.	Flow, per second.		Horsepower, gross.		Utilized.		Gross horsepower available, with fall used.
		Minimum.	Ordinary summer.	Minimum.	Ordinary summer.	Horsepower, net.	Fall.	
	Square miles.	Cubic feet.	Cubic feet.	Per foot fall.	Per foot fall.		Feet.	
At mouth...........	448	224	336	25.4	38.2	100+	12.0	304
At Manchester.....	329	164	246	18.6	28.0	20	3.5	65

In the foregoing estimate 0.5 cubic foot per second per square mile was assumed as the minimum flow, and 0.75 cubic foot per second per square mile as the ordinary low-water flow. These figures are very high—perhaps too high—but a series of gaugings only can serve as a correct guide.

The power of the stream was formerly utilized by one cotton-factory and a number of saw- and grist-mills. The first mill is 2½ miles from the mouth, with a fall of 12 feet, not subject to interruption, except sometimes for a day or two by backwater from the Cape Fear. At Manchester was the cotton- and woolen-mill of the Linwood Manufacturing Company, using a fall of 3½ feet and about 20 horsepower, but this has been abandoned for some years. Just above the railroad crossing at Manchester there is a small saw-mill operated entirely by water-power.

The Manchester mill, a cotton-factory of about the same size, uses power from a small tributary. It contains 55 looms and 2200 spindles. There is a dam 18 feet high and 60 yards long, giving a fall of 22 feet. The power obtained from this stream is estimated to be 35 horsepower during half the year. This is supplemented by steam-power. There are doubtless many places on Lower Little river where dams might be located and excellent power obtained.

Upper Little river is a stream similar to Lower Little river, except that it is still less of a sand-hill stream, and said to be not so bold or so reliable as the latter. It is only used for saw- and grist-mills, and there are, no doubt, sites not used. Each of these streams is about

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[1] The elevation above tide at crossing of Raleigh and Augusta Air-Line railroad is about 221 feet, and at mouth say 31 feet. Length, measured from map, is about 55 miles.

100 feet wide at its mouth. The length of Upper Little river is about 32 miles, measured in a straight line, its drainage area 176 square miles, and its fall, from the crossing of the Raleigh and Augusta Air-Line railroad to its mouth, about 290 feet, or perhaps at the rate of 6 feet or over to the mile.

On the numerous small streams in Cumberland county there are undeveloped and partially developed waterpowers which would serve to operate saw- and grist-mills and even larger manufacturing establishments.

Above Upper Little river there are no tributaries to the Cape Fear which are worth mentioning specially, although there are some small creeks which afford good small powers, and are utilized for grist- and saw-mills.

THE CAPE FEAR TRIBUTARIES—HAW RIVER.

This river rises in Rockingham and Guilford counties, North Carolina, pursues a general southeasterly course through Alamance, a corner of Orange and Chatham counties, and in the southeastern corner of the latter unites with the Deep river to form the Cape Fear, which has just been discussed. The length of the stream, following its general course, is about 80 miles, but considerably more if all its windings are followed. Near the northwest corner of Alamance county the river forks, the north fork going by the name of Haw river, while the south fork is known as the Reedy fork of Haw river. The Reedy fork, as well as the north fork in its upper parts, flows nearly east, but the course of the stream below the junction of the two is nearly southeast. There are no large towns on the river, Haw River, at the crossing of the North Carolina railroad being about the only town, but Graham, the county-seat of Alamance county, and Burlington, are only a few miles distant.

The drainage area of the Haw river comprises about 1675 square miles, and the stream receives two important tributaries: the New Hope creek, from the east, draining about 317 square miles, entering about 3 miles above the junction of Haw and Deep rivers, and Alamance creek, from the west, draining about 237 square miles and entering the Haw river about 4 miles south of Graham. The Reedy fork receives as its principal tributary Buffalo creek, from the south, draining about 128 square miles, and the north fork receives Troublesome creek, from the north, with a drainage area of about 88 square miles. The map shows the position of all these streams.

Haw river flows through a fertile country lying in the center of the cotton-belt, and the productions of which are about the same as along the upper part of the Cape Fear, viz. corn, cotton, wheat, oats, rye, tobacco, grasses, a great variety of vegetables and fruits. It is tolerably well wooded, although not enough care is taken to preserve the forests. Topographically, the region, especially in the lower part, is more broken than the drainage basins of the Neuse, the Tar, or the Roanoke rivers. The mineral resources of the basin are considerable, iron being found in various places in quantity and of good quality. Copper has also been found, but the mines have been little worked. Building stone of good quality is found all through the basin.

The bed of the stream is generally rock, covered in places with deposits of sand, gravel, or clay, but affording almost everywhere excellent foundations for dams. The banks on the lower part of the stream are tolerably high, in some places very steep, and the bottoms are narrow and not much subject to overflow, while in the upper part of the stream, where the country is not so broken, the banks are, in places, low. In the upper parts of Alamance and Guilford counties the country is much flatter than in Chatham county. The stream is subject to very heavy freshets, and there are no lakes serving to restrain their violence; but the stream is rarely frozen over, and the mills suffer no trouble with ice. Some of the tributaries of the stream rise in a region where the prevailing rock is a slate, which is covered with a thin soil and sometimes with none at all; and from this region the rain-water is shed very rapidly, so that these small streams are nearly dry in summer. The lowest stage of flow on the Cape Fear river of which we have any record (1897) was equivalent to a discharge of 0.076 cubic foot per second per square mile of drainage area, while the mean discharge for an entire month (October, 1897), including freshets, was only 0.12 cubic foot per second per square mile. The facilities for the construction of storage-reservoirs are said to be good in the upper part of the stream, though no surveys or examinations have ever been made with a view to determining this point accurately.

The rainfall in the valley of the Haw river is about 45 inches, distributed as follows: spring, 12; summer, 12; autumn, 11; winter, 10; its distribution throughout the year appears to be quite uniform.

The fall of the stream between different points will be seen from the following table, which gives the elevation at several points; and it will be remarked that the fall of the stream is quite large for one not rising in the mountains, being much larger than that of any stream, or of any part of a stream, which we have yet considered, which lies in the middle division:

TABLE OF DECLIVITY—HAW RIVER.

Place.	Distance from mouth.[1]	Elevation above tide.	Distance between points.	Fall between points.	Fall between points per mile.
	Miles	Feet.	Miles	Feet.	Feet.
At confluence with Deep river	0	130	50	346	6.9
At crossing of North Carolina railroad	50	476	27	171	6.3
Haw river (North Fork), at crossing of Piedmont Air-Line	77	647	30	200	6.7
Reedy fork, at crossing of Piedmont Air-Line	80	676			

The flow of the stream in different seasons is not known with accuracy. Professor Kerr states the flow at its mouth to be 1760 cubic feet per second, but as this is not low water, and probably more nearly the average flow, it is of no value for our computations. It is therefore necessary to base our figures, as usual, on estimates from drainage area and rainfall. A statement of the results of flow measurements made on Haw river about 1 mile above its mouth will be found on p. 301. Measurements on the Cape Fear at Fayetteville are given on pages 302-305.

Haw river (crossed almost at right angles by three railroads) is not very accessible. Especially is this the case with that part of the river below the crossing of the North Carolina railroad at Haw River, in Alamance county, while above that point the stream is, on the average, about 8 miles from the railroad, to which the Reedy fork runs nearly parallel.

WATERPOWER ON HAW RIVER.

The foregoing general sketch shows that the Haw river ought to afford a great deal of waterpower on account of its rapid fall and the fact that it crosses the ledges of rock at large angles, and the following account of the power on the stream will show that this is the case, and that the Haw river is well fitted, in some respects, to become a considerable manufacturing stream, and indeed it is at the present time one of the principal manufacturing streams of the state.

Commencing at the mouth of the river the waterpowers met with, in ascending the stream, will now be described.

BLAND MILL SITE.—The first power is situated 3 miles from the junction, and just below the mouth of New Hope river. It was formerly utilized by a mill belonging to the American Iron and Steel Company, and known as the "Bland mill." The banks on the east are favorable for building, and not often subject to overflow, while on the west rises a rocky bluff to a height of over a hundred feet, which can supply an abundance of stone for the construction of a dam and foundations. Diagonally across and up the river from the east bank to this rocky bluff extended a dam, a wooden structure, 300 feet long, 7 feet high, vertical in front, but sloping downward on the up-stream side, and throwing the water back for over a mile, with an average width of 200 feet, the river not being thrown out of its banks. At the east end of the dam was a grist-mill, running two pair of stones, with 7 feet fall, and using perhaps 20 horsepower net. This mill was run during eleven months of the year, but during the remaining month was troubled with backwater on account of the small fall. There was at all times, of course, a great excess of water. In the summer of 1880 about 80 feet of the dam at the western extremity was undermined and carried away by a freshet. It was subsequently rebuilt, but was again washed away. The river here is about 250 feet wide, and the water rises very high in freshets, sometimes 20 or 30 feet, but there is no trouble with ice. The drainage area above this power being about 1675 square miles, the power is estimated as in the following table:

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[1] Distances based on measurements from a map, made to follow the windings as closely as was practicable.

[2] Professor Kerr's statement is that the river affords 200 horsepower per foot of fall at its mouth. (Geol. Rep., p. 39.)

TABLE OF POWER AT THE BLAND MILL.

State of flow.	Drainage area.	Fall.	Flow per second.	Horsepower available gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	7 feet fall.
Minimum	1,675	7	280	82.3	225
Minimum, low season			335	98.0	270
Low season, dry years			380	43.5	300

The effect of the uniform distribution of the rainfall is to render the flow more variable and to decrease the minimum flow, while at the same time the total amount of power or flow available, with storage, is increased beyond what it would be were the summer fall greater. It is stated that the flow of this stream is very variable. To render the maximum flow available, with storage, would require the construction of storage-reservoirs with a capacity in all of at least 900,000,000 cubic feet, which would require, for instance, if only one reservoir were used, one of say 2 miles square and between 8 and 9 feet deep. Such a large amount of storage would, of course, be very expensive. The pond at the Bland mill was, of course, not large enough to furnish any appreciable storage, or to allow of the concentration of the available power into working hours. The site is not an especially good one for large establishments on account of the small fall and the trouble resulting from backwater. It is, however, very favorably located within a few miles of the Raleigh and Augusta Air Line railroad, and in a healthy part of the state.

HARTSAWS MILL SITE.—The next power above this is situated about 2 miles further up the stream, and is not improved. It is known as Hartsaws site, and it is said that the available fall amounts to 6 feet. Being above the mouth of the New Hope, the drainage area amounts to about 1320 square miles, and the power available will be about 0.67 of that at the Bland mill, or as follows:

POWER AT HARTSAWS SITE.

State of flow.	Drainage area.	Fall.	Flow per second.	Horsepower available, gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	6 feet fall.
Minimum	1,320	6	218	24.7	150
Minimum, low season			264	30.0	180
Low season, dry years			300	34.0	200

MOORES MILL SITE.—The next power is Moores mill, improved and in use, situated some 3 miles above Hartsaws. There is no dam, but a race some 200 yards long leads to the mill—a grist-mill, with 2 or 3 run of stones. Formerly there was also here a saw-mill, cotton-gin and foundry, using a fall of some 10 feet and a small amount of power. The shoal is about a mile long, and the total fall is said by good judges to be about 22 feet; but the place has not been examined, and this statement cannot be vouched for. In dry weather a rough dam of stone turns the water into the race, but this is disturbed in freshets, and in ordinary times is not necessary. The power formerly used we are unable to state exactly; that available, assuming the fall to be 22 feet, is estimated in the following table:

POWER AT MOORES MILL.

State of flow.	Drainage area.	Fall assumed.	Flow per second.	Horsepower available, gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	22 feet fall.
Minimum	1,300	22	214	24.0	525
Minimum, low season			260	30.0	660
Low season, dry years			295	33.7	740

This site, one of the best on Haw river, is quite easily accessible, being only about six miles from the Raleigh and Augusta Air Line railroad, and about the same distance from Pittsboro, the county-seat of Chatham county. It is well worthv of the attention of capitalists desiring to locate in this vicinity.

WILLIAMS MILL SITE.—The next power is about 1½ miles above Moores mill and is known as Williams mill. It is a small saw- and grist-mill and foundry, all very much in need of repair. There is a fall of about 7 feet in use, but the dam could be raised and from 3 to 4 feet more obtained without overflowing any valuable land. The site, however, is not a very good one for a mill of any size, as the river is divided by an island half a mile long or more and the river is very wide. The pond is about 450 yards long, and starting from its head there is a fall of 12 to 14 feet in the next three-quarters of a mile. The river is, however, full of little islands.

Next comes a second unimproved site, known as the Seven Island shoal, where the fall is said to be 7 feet. It is 2 miles above the one last mentioned, and the power is tabulated beyond.

HENLEY'S MILL SITE.—Next comes the mill site formerly owned by Stephen Henley, now owned by W. L. London of Pittsboro, about 1½ miles above Seven Islands, and just about on the road from Pittsboro to Raleigh, and 12 or 13 miles from the mouth of the stream. A wing-dam 500 feet long and 3½ feet high extended across to an island and served to turn the water into the race, which carried it about 100 yards, affording a fall at the mill of 8 feet. The dam was built in 1874 and 1875 at a cost of some $500, and is of rock, planked over, and backed the water some 600 feet. There was here formerly a grist-mill, which used about 50 horsepower. It was situated on the west bank, but the principal channel of the river is on the east side of the island above referred to, which is about half a mile long. The mill is not now used. The fall at this place is estimated at about 16 feet. Taking this estimate as correct (though we cannot vouch for it), the available power at this place may be estimated as follows:

TABLE OF POWER AT HENLEY'S MILL.

State of flow.	Drainage area.	Fall assumed.	Flow per second.	Horsepower available, gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	16 feet fall.
Minimum	1,285	16	200	22.7	360
Minimum, low season			260	30.0	480
Low season, dry years			295	33.7	540

The next power is Brown's old mill site now owned by Daniel Tillman. The fall here is about 6 feet in 350 or 400, over loose rock bottom. The east bank of the stream here is rather soft and muddy and a good dam could not be built. Two mills have been washed away here, and the site is of very little importance.

The next is an unimproved fall of some 8 feet, belonging to the

Bynum Manufacturing Company, formerly used, but now altogether abandoned. The estimated power is given in the table.

BYNUMS MILL.—The most important waterpower on this portion of the river is that at Bynums, four miles above Henley's mill and 17 miles above the mouth of the river. Here is located the cotton-mill of the Odell Manufacturing Company (containing 4500 spindles), a cotton-gin, corn-mill, and roller flour-mill, all operated by water from the same race. The dam is 3½ feet high and 500 feet long, ponding the water over 10 or 12 acres. A race 600 yards long leads to the mill, where the fall is 16 feet and the power developed is about 125 horsepower.

The following table gives the estimated flow and power:

TABLE OF POWER AT BYNUMS.

State of flow.	Drainage area.	Fall.	Flow per second.	Horsepower available, gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	16 feet fall.
Minimum	1,250	16	200	23.4	375
Minimum, low season			250	28.4	450
Low season, dry years			280	32.4	510

One mile or less above Bynums is R. J. Powell's mill site, the mill having been burnt some years ago. The dam was of wood and stone, extending entirely across the river, and a fall of about 7 feet was used.

Less than a mile above Powell's is Burnett's unimproved site, where the available fall is said to be about 6 feet.

PACE'S MILL.—A short distance above this is Pace's mill. The dam here is 100 feet long and 8 feet high, from which a race 450 feet long leads to the mill, where a fall of 14 feet is used. Mr. Pace has a flour- and corn-mill, with four pair of stones, a saw-mill, wagon-shop and blacksmith-shop. He writes that upon his property, which extends for three-quarters of a mile along the river, there are two sites not used—one below the mill, with 10 feet fall, and another above, with 13 feet fall—available, with a dam 4 feet high, 600 feet long, and a race 600 feet long.

TABLE OF POWER AT PACE'S MILL.

State of flow.	Drainage area.	Fall.	Flow, per second.	Horsepower available, gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	14 feet fall.
Minimum	1,209	14	192	21.8	305
Minimum, low season			237	27.0	378
Low season, dry years			273	31.0	434

The next mill above Pace's is Love's, about three miles above, but between the two it is said that there are several sites not used. The river is said to be quite rapid at this point of its course. At Love's mill there is a dam across the river 700 feet long, giving with a race 400 yards long, a fall of 11 feet at mill, which is a grist- and saw-mill.

Above Pace's mill, and about 2½ miles from Love's mill, there is the old site of the Willis Dark mill. There was a grist-mill here, but at present both mill and dam are gone. The fall is small—about 6 feet in nearly a mile—but a good dam could be built and there is ample building room.

TABLE OF POWER AT LOVE'S MILL.

State of flow.	Drainage area.	Fall.	Flow per second.	Horsepower available, gross.	
(See pages 54 to 59).	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	11 ft. fall
Minimum	1,155	11	184	20.9	230
Minimum, low season			230	26.1	280
Low season, dry years			260	29.5	320

Above Love's mill, the first site is known as the "Jeanes'" fall. Here there is a fall of about 6 feet in 600, over rock ledges. The location is not a very good one for building a dam.

The first improved power above is some ten miles farther up, in Alamance county, near the Orange line. Before leaving Chatham county it may be said that, according to the foregoing, it is clear that Haw river offers a large amount of power in its course through the county, very little of which is utilized, but a large proportion of which is available. The bed and banks are almost everywhere good, the country hilly, but not mountainous, and the climate healthy. A disadvantage in the use of the small falls which have been mentioned lies in the sudden and large rise to which the river is subject on account of the narrowness of the bottoms. Although in some places the fall is considerable in a short distance, yet on the whole the declivity of the stream seems to be tolerably uniform, while the width of the stream seems to be on an average some 400 feet or more.

SAXAPAHAW.—The next power above Love's mill is Saxapahaw factory, near Saxapahaw. The dam extends entirely across the stream, and is about 375 feet long and 3 feet high, built of wood in 1878 and 1879, and backing the water about a mile, with an average width of 350 feet. A race a mile long leads to the factory, where 160 horsepower is said to be developed with 19 feet fall. The mill is a cotton-mill, containing 4704 spindles and 100 looms. Estimates of the power will be found in sufficient detail in the table giving the summary. This mill being above the mouth of the Big Cane and several other creeks, the stream is considerably smaller than at Love's.

NEWLIN'S MILL.—The next power above Saxapahaw is at Newlin's grist-mill. The dam, now in bad condition, is of wood and stone, 900 feet long and 5 feet high, built in 1875 at a cost of $3500; and from it leads a race, 400 yards long and 10 feet wide, conducting the water to the mill, where the fall is 9 feet, the power used being probably some 40 horsepower net, with three turbine-wheels. The pond covers some 30 or 40 acres, with an average depth of 6 feet or over, but the stream is not thrown out of its banks. This power is located 2½ miles above Saxapahaw in Alamance county. The power is estimated in the table on p. 155.

The next power is an undeveloped one owned by the Virginia Cotton-Mills Company, of Swepsonville, Alamance county. There was formerly a grist-mill here, operated by Seymour Puryear, but this has long since gone down. The available fall here is some 7 or 8 feet, and we understand that a project is now on foot to develop this site and transmit the power electrically to Swepsonville, about one mile above.

VIRGINIA COTTON-MILLS.—The next mill is that of the Virginia Cotton Mills Company. This mill contains 200 looms and 4160 spindles. The dam is of wood, 550 feet long, 7 feet high, built in 1876 at a cost of about $3000, and frôm it a race 450 yards long leads to the mill, where the fall is 13 feet and the power used 160 horsepower, developed by two 61-inch turbine-wheels. Full capacity can be obtained all the time except in the dryest seasons. The factory was burned in June, 1881, but has been rebuilt.

GRANITE COTTON-MILLS.—We next come to the Granite cotton-mills, owned by the Thomas M. Holt Manufacturing Company, at Haw River, just above the crossing of the North Carolina railroad. These mills contain 8500 spindles and 436 looms, all operated by waterpower. The dam is of wood and stone, 640 feet long and 12 feet high, and backs the water about 1¾ miles. There is no race, the mill being located directly at the dam. The working head is 12 feet and the power developed is 450 horsepower, developed by two 60-inch turbines, set in a forebay of masonry costing about $25,000 (fig. 14). These mills are frequently troubled by lack of water in dry seasons, and have an auxiliary steam-plant.

At the head of the Granite mill pond is Sellers' mill site, not now used, said to have 12 feet fall.

Juanita Cotton-mill.—Two and one-half miles above is the Juanita cotton-mill, containing 6300 spindles. The fall here is 14 feet, 7 being given by the dam, which is of wood and 467 feet long, backing water for three-quarters of a mile. The race is 200 feet long. The power developed is 136 to 140 horsepower, given by two 58-inch turbine-wheels. In very dry seasons about one-half day a week is lost for want of water. The company also operates a small grist-mill.

Carolina Cotton-mill.—About one mile above the Juanita mill is the Carolina cotton-mill (J. H. & W. E. Holt & Co.), which contain 58 looms and 3070 spindles. The dam was built in 1868, and is a frame dam with stone abutments about 200 feet long and 6 feet high, making a pond of 3 acres and giving a fall of 15 feet at the mill, three-quarters of a mile below, where 150 horsepower is used.

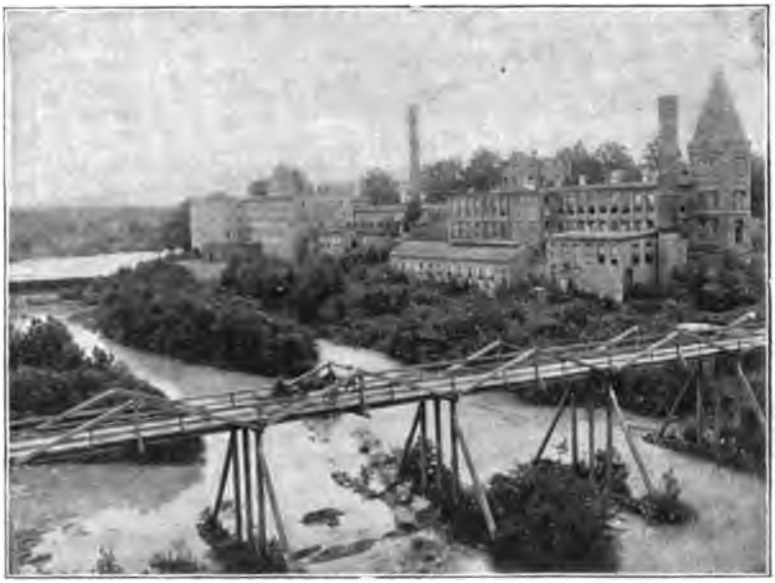

FIG. 14.—GRANITE COTTON MILLS, HAW RIVER.

Glencoe Mill.—One mile above is the Glencoe mill, containing 186 looms and 3500 spindles, on the site of the old Company mills. The dam, constructed of stone and wood, was built long ago and is about 320 feet long and 9 feet high, giving a fall of 15 feet with a race 400 yards long. It is claimed that 160 horsepower can be obtained during at least 90 per cent. of the time.

Two and one-half miles north of Burlington is an old grist-mill (Ireland's) not now used. The fall is said to be 6 feet.

ALTAMAHAW COTTON-MILL.—The highest power on the river is about 5 miles from Gibsonville station on the North Carolina railroad. This is the site of the Altamahaw cotton-mill, owned by Holt, Gant & Holt, containing 394 looms and 6500 spindles. The dam is 350 yards above the mill and is 300 feet long and 15 feet high, backing the water three miles. The fall at the mill is 20 feet, and the horsepower used in the mill is 300, 50 of this being obtained from the engine, which is used all the time. The dam is of stone, built some years ago.

From the above sketch it will be seen that the waterpower on Haw river is quite extensively used, especially on the upper parts where the stream is more accessible. Haw and Deep rivers, together with the south fork of the Catawba, yet to be described, are, in fact, the principal manufacturing streams of North Carolina.

SUMMARY OF POWER OF HAW RIVER.

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross.[1]			Utilized.		Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season.	Low season, dry years.	Horsepower, net.	Fall.	
	Miles.	Square miles.	In.	In.	In.	In.	In.	Feet.	Feet.					Feet.	
Bland mill	3.0	1,675	12	12	11	10	45	7.0	....	225	270	300	......	7.0	
Hartsaws site	5.0	1,320	12	12	11	10	45	6.0	....	150	180	200	......	......	Not improved.
Moores mill	8.0	1,300±	12	12	11	10	45	22.0	5,280	525	660	750	......	10.0	
Williams mill	10.0	1,295±	12	12	11	10	45	10.0	....	190	240	270	......	7.0	
Seven Island shoal	12.0	1,290±	12	12	11	10	45	7.0	....	170	210	240	......	......	Unimproved.
Henley's mill	13.5	1,285	12	12	11	10	45	16.0	....	360	480	540	......	......	
Browns mill	15.0	1,275±	12	12	11	10	45	6.0	....	165	200	230	......	......	
Bynums site	16.5	1,260±	12	12	11	10	45	8.0	....	190	270	260	......	......	
Bynums factory	17.5	1,250	12	12	11	10	45	16.0	....	375	430	510	125	16.0	
Powell's site	18.0±	1,240±	12	12	11	10	45	7.0	....	155	190	220	......	......	Mill burnt; dam still there.
Burnett's site	18.5±	1,230±	12	12	11	10	45	6.0	....	130	165	190	......	......	Not improved.
Pace's mill	20.0±	1,209	12	12	11	10	45	14.0	....	306	378	434	75±	14.0	
Several unimproved sites	....	....	12	12	11	10	45	....	....	......	......	......	......	.....	
Love's mill	22.0±	1,155+	12	12	11	10	45	11.0	....	230	280	320	?	?	Probably not over 50 horsepower used.
Saxapahaw factory	38.0±	967	12	12	11	10	45	19.0	....	310	400	460	160	19.0	
Newlins mill	41.0±	935±	12	12	11	10	45	9.0	....	160	200	230	40	10.0	
Unimproved site	....	....	12	12	11	10	45	8.0	....	......	......	......	......	......	
Virginia cotton-mill	45.0±	670±	12	12	11	10	45	18.0	....	140	190	220	160	18.0	? See description, p. 152.
Granite cotton-mills	50.0±	585	12	12	11	10	45	12.0	....	110	150	170	450	12.0	? See description, p. 152.
Sellers mill site	52.0±	....	12	12	11	10	45	12.0	....	......	......	......	......	......	
Juanita cotton-mill	55.0±	494	12	12	11	10	45	14.0	....	102	140	161	150	14.0	Expect 150 horsepower.
Carolina mill	55.0±	490±	12	12	11	10	45	15.0	....	110	150	175	150	15.0	
Glencoe mill	56.0±	475±	12	12	11	10	45	15.0	....	106	145	169	160	15.0	Expect 160 horsepower.
Ireland site	58.0±	460±	12	12	11	10	45	6.0	....	......	......	......	......	......	
Altamahaw mill	63.0±	450(?)	12	12	11	10	45	20.0	....	126	186	200	250	20.0	

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[1] For explanation of powers estimated see pages 54 to 59. Power much larger than in last column during nine months of the year.

THE TRIBUTARIES OF HAW RIVER.

The first considerable tributary met with in ascending the river is *New Hope river*, which enters from the west, after flowing through Orange and Chatham counties, and draining an area of some 317 square miles. The substance of what can be learned regarding this stream is that it is generally sluggish, flowing through a level country, and without waterpower of any importance, the only mills being a few small local grist-mills and saw-mills. The power used is tabulated farther on.

CLOVER ORCHARD AND SNOW CAMP MILLS.—The succeeding tributaries of the Haw river are small and unimportant until we reach *Cane creek*, which enters from the west, at the extreme southwest corner of Orange county. It rises in the extreme west of Alamance county, with some tributaries from Chatham, and flows very nearly due east and only a mile or so from the county-line, but without leaving Alamance. It has more fall than the streams entering Haw river from the east, but is specially mentioned chiefly on account of its having had located on it one factory, the Clover Orchard cotton-factory, which is situated some 10 miles from its mouth. The length of the stream, in a straight line, is about 20 miles, and its drainage area 73 square miles. The factory above referred to was closed some years ago and the machinery removed. With it was connected a grist-mill, both using a fall of 23 feet and 50 horsepower, which could be obtained during nine months of the year, the average during the remaining three months being 25 horsepower, during which period auxiliary steam-power was used. The mill being run only during 12 hours, and there being no waste at night in dry seasons, the natural flow of the stream would afford only, say, 10 horsepower in low seasons, and probably much less when at its lowest. The dam is of rock, 120 feet long and 17 feet high, and backs the water about a mile; the factory is 300 yards below.

A mile or more above the old Clover Orchard factory site is the Snow Camp woolen-mill, which contains 11 looms and 400 spindles. A dam 12 feet high and 70 feet long gives a fall of 16 feet, and is claimed to develop 40 horsepower during the larger part of the year. This is supplemented by a small steam-plant.

ALAMANCE AND BELLEMONT COTTON-MILLS.—The next important tributary is *Alamance creek*, which rises in the eastern part of Guilford county, pursues a general direction nearly due east, emptying into Haw river about 4 miles below the railroad crossing. Its length is in the neighborhood of 25 miles, and its drainage area about 237 square miles. It receives as tributaries two creeks called Little Alamance, from the north, and Stinking Quarter creek, from the south. There are only two powers on the stream worth mentioning, viz. Alamance cotton-factory (E. M. Holt's Sons) and Bellemont cotton-mill (L. B. & L. Holt).

ALAMANCE COTTON-MILL contains 94 looms and 960 spindles, using about 50 horsepower. The dam is of stone, 10 feet high and 125 feet long, and with a race 250 yards long, gives a fall of 12½ feet at the mill. There is a supplementary steam-plant that is used during very dry seasons.

THE BELLEMONT MILL is located on Big Alamance creek about 5 miles from Burlington. It contains 2592 spindles and 126 looms and uses about 150 horsepower, developed for nine months of the year by water, for the other three it is necessary to supplement this with steam. The dam is 11 feet high and 100 feet long, built of wood. There is no race, the wheel-house being situated directly at the dam.

REEDY FORK.

The Reedy fork of Haw river and the other tributaries and forks in the upper part of the drainage basin offer some powers utilized to some extent by saw- and grist-mills, and one cotton-mill (the Ossipee). The country is quite flat in the upper part of the basin, and there are no falls in the streams.

OSSIPEE MILL.—The Ossipee mill is located on the south side of Reedy fork, about 1½ miles above the junction of this stream with Haw river. It contains 300 looms and 3600 spindles. The dam is 10 feet high and 150 feet long, giving a fall of 11 feet at the mill and developing 160 horsepower during nine months. This is supplemented by steam during the dry season.

THE CAPE FEAR TRIBUTARIES—DEEP RIVER.

This stream rises in the western part of Guilford county, North Carolina, near the sources of the Haw river, flows in a southeasterly direction through Randolph county and into Moore, where it bends quite abruptly, and flows a little north of east into Chatham county, where it joins the Haw to form the Cape Fear. Its length is about the same as that of the Haw river, and its drainage area is 1350 square miles. It has only one important tributary, Rocky river, from the north, which enters Deep river about 4 miles above Lockville, and drains an area of 205 square miles, all in Chatham county. The most important towns on Deep river are Lockville, near the mouth, Franklinville, Cedar Falls, Ramseur and Randleman, in Randolph county.

The drainage basin of Deep river resembles that of Haw river so closely that it is not necessary to describe it in detail. In its lower part the river flows, with a tortuous course, through a narrow valley with abrupt banks, and, in a few cases, perpendicular and overhanging cliffs some 100 feet high.

The rainfall on the basin is a little greater than on that of Haw river, with rather more rain in winter, as will be seen from the maps in the Smithsonian publications. The flow of the river is rather more variable, owing probably to the fact that a greater number of its tributaries rise in the slate country and become nearly dry in summer. For the same reason. the freshets are, on the whole, more violent, and the river rises oftener above its banks, overflowing the bottoms on the lower part to a depth of 10 or 12 feet. On the upper part of the river there are probably sites for reservoirs, although Guilford and the neighboring counties are, on the whole, not very favorable for their construction, being too flat.

The following are some elevations on the stream, with distances measured from the map, and resulting declivities:

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Difference of elevation.	Fall per mile between points.
	Miles	Feet.	Miles	Feet.	Feet.
Mouth, or confluence with Haw	0	130	14	83	5.9
Near Egypt mine. (C. F. & Y. V. crossing is 204.60)	14	213	74	412	5.6
Northern part of Randolph county	88	625			
Crossing of Piedmont Air Line railroad	100	715	12	90	5.7

From this it appears that the fall of the stream is not much different from that of Haw river, though greater in its upper part.

Gaugings of the Cape Fear river at Fayetteville have been made by the U. S. Weather Bureau and the U. S. Army engineers for 20 years; and by the U. S. Geological Survey and State Geological Survey for three years (see pp. 302-305); and gaugings of Deep river, a short distance above its junction with the Haw, have been made during the past year (p. 301).

As will be seen from the map, the river is now fairly accessible, being crossed by the Durham and Charlotte railroad near Carbonton, and by the Southern railroad near Jamestown, and being tapped by the C. F. & Y. V. railroad at Gulf, Cedar Falls and Ramseur on the northeast side of the river, and by the Southern railroad at Randleman on the southwest side. A number of manufacturing establishments have been located at various points, especially in Randolph county, shipping their products by the railroad lines just mentioned.

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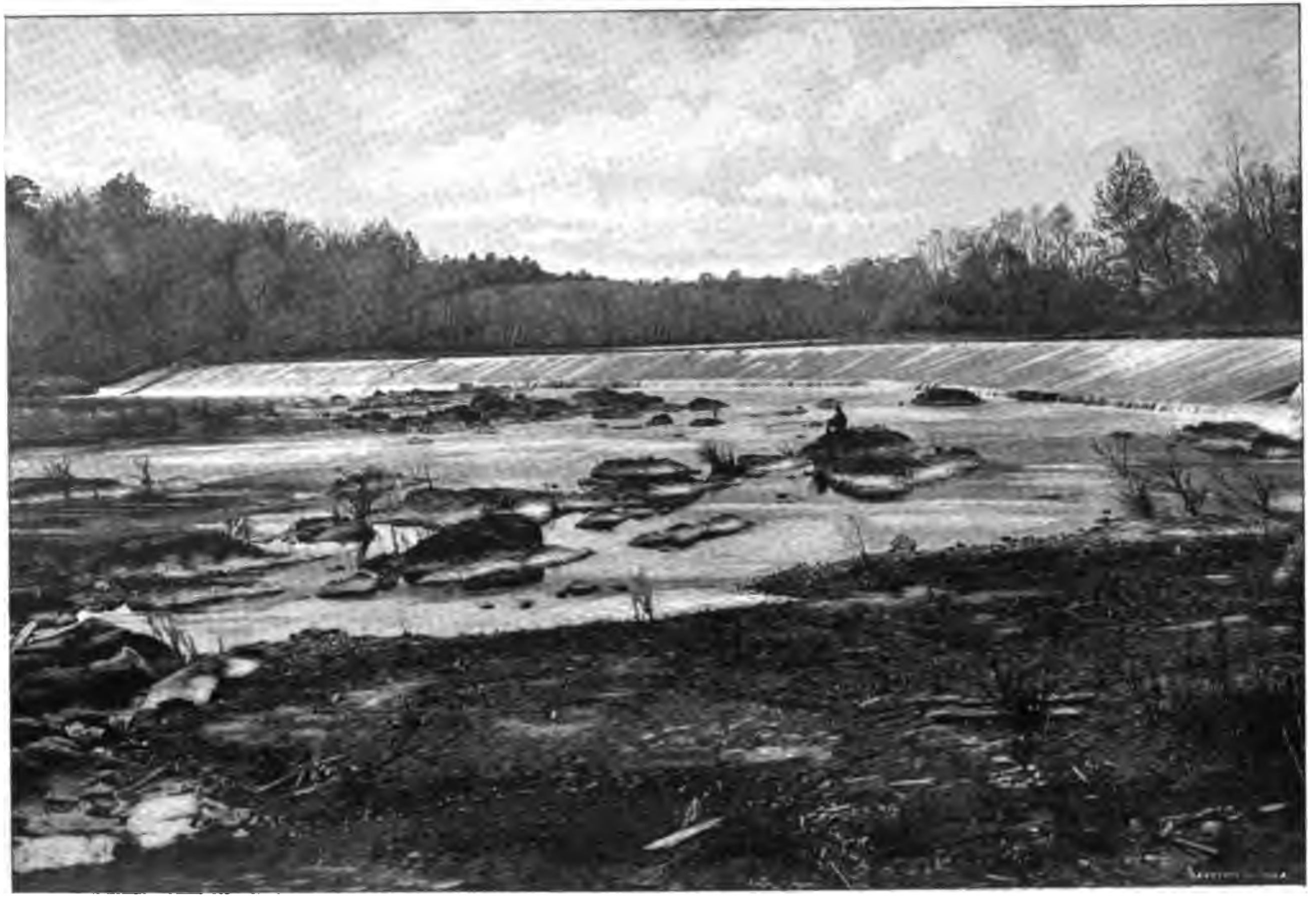

LOWER DAM, LOCKVILLE, N. C., DEEP RIVER

WATERPOWER ON DEEP RIVER.

The following are the more important mills and sites:

LOCKVILLE.—The first power on the river is at Lockville, about 2 miles from the mouth of the river. The falls, known as Pullins falls, were overcome by the Navigation Company,[1] and navigation established around them by means of 2 dams and a canal leading down the river from the lower one, with an outlet-lock into the river at the lower end of the town, with a single lift of 24 feet. The lower dam is 600 or 700 feet long, 11 feet high, built of crib-work filled with stone, with a vertical back, and a face sloping down to about 1 foot above low water, the base being 30 feet wide, up and down stream. It is said to have cost about $14,000. It does not extend straight across the river, but has the shape of a letter V, apex up-stream (Plate V), and backs the water half a mile,with an average width of about 700 feet, to the upper Lockville dam. The foundation is rock, and the dam is not, to any great extent, liable to injury by freshets. The canal which leads from the dam is less than half a mile long, with a guard-lock at its head having a lift of two feet, and the high lock at its outlet below. All along this canal are magnificent sites for mills, which could use a fall varying between 11 and 24 feet, with perfectly safe locations. The following mills were in use in 1881, all owned by the Navigation Company, viz. 1 cotton-gin, 14 feet fall; 1 saw-mill, 16 feet; 1 grist-mill, 16 feet; 1 foundry, 18 feet; 1 grist-mill, 18 feet; 1 machine-shop, 18 feet; all on the canal, fed directly from it, and discharging the water into the river. The aggregate power used by these mills was not exactly known, but was, perhaps, in the neighborhood of 150 horse-power. Since that time the foundry and saw-mill have both been burned and abandoned; and the machine-shop has been replaced by a roller flour-mill, capacity 40 barrels a day, owned by John Barringer. The other sites and the general power are now owned by the American Iron and Steel Company. There was always a waste of water, and there were about 15 days in the year when there was trouble with backwater, the river at the outlet-lock being probably less than 300 feet wide. In high freshets the water rises 5 feet on the dam. The canal was 40 feet wide, and originally 6 feet deep. With a fall of a foot to the mile it could probably be made to carry the entire flow of the stream at low water; so that the entire power at this place is really at present available, except that the wood-work of all the dams of the company was in bad condition, badly rotten, and there was considerable leakage.

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[1] See page 128.

The drainage area above this place being about 1350 square miles, the flow and power are estimated as in the following table:

TABLE OF POWER AVAILABLE AT LOCKVILLE.

State of flow.	Drainage area.	Fall.	Flow, per second.	Horsepower available, gross.	
(See pages 54 to 59.)	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	24 feet fall.
Minimum	1,350	24	216	24.5	590
Minimum, low season			256	29.1	700
Low seasons, dry years			298	33.8	800

In our opinion in low water the reservoir room would be sufficient to allow of the concentration of power into 12 hours to such an extent as to increase the minimum power by 50 per cent. at least.

This power is an excellent one in all respects. A branch of the Raleigh and Augusta Air Line railroad leads directly to the mills. There is an abundance of fine building stone in the neighborhood. There is no trouble with ice, and little with high water. The river is navigable up to Carbonton, so that the copper deposits near Cumnock, the coal-beds and the iron ores of the valley are easy of access. The location is healthy, and indeed there seems to be no reason why a large amount of power should not be utilized at this place. The two Lockville dams, the Gorgas site, and the Buckhorn and Battles falls properties have been purchased recently (March, 1899) by a new electric power company, and are to be developed at an early date.

The second Lockville dam, half a mile above the first one, was of similar construction, and extended straight across the river, its length being about 700 feet, its height 16 feet, and its pond 2 miles in length, up to the Gorgas canal, with an average width of about 600 feet. This dam has been largely washed away, and it would probably cost some $12,000 to rebuild it. The lock at its north end is 115 feet long, 18 feet wide, with a lift of 16 feet. The banks between this dam and the one below are steep and rocky on the north side and shelving on the south. The available power here could best be used on the south side, unless it were desired to use it at Lockville, in which case a canal or flume should be built on the north side. A canal 20 feet wide and 6 feet deep would probably suffice to carry the minimum flow, with a fall of 1½ feet per mile. During the war there was a grist-mill on the right bank, but the dam was not sufficiently secured, and it was washed around at this end. It was rebuilt in 1874, when the last company put the works in order, and 150 or 200 feet of the south part were put in, at a cost of $10,000, several accidents happening during the work. The power at this dam was easily available, although there had been no steps taken to utilize it. The amount of water is the same as at the lower dam, and the available power less in proportion to the fall, *i. e.* two-thirds of that in the last table. In this case, too, the reservoir-room would probably be ample to allow of the concentration of power and to render double the low-season flow available during 12 hours.

GORGAS DAM.—Two and a half miles above the second Lockville dam was located the Gorgas dam, just below the mouth of Rocky river, extending straight across the river, about 600 feet long and 7 feet high, built of cribs filled with stone, vertical on both sides, and with a width of 6 or 8 feet, and backing the water up to the Endor dam, a distance of about 7 miles or a little less, with an average width of about 500 feet. It was washed away some years ago. This dam was at the head of a canal half a mile long, the third of the navigation canals, with guard- and outlet-locks, at the latter of which was a grist-mill taking water from the canal, using 7 to 8 feet fall and perhaps 20 or 25 horsepower, with 2 run of stones. Full capacity could be secured all the time, except for about 15 days in the year, when the river is high. The location is a very favorable one for building, and all the available power could easily be utilized along the canal, which is of ample capacity to carry the dry-weather flow. The drainage area above this place is about 1300 square miles, and the amount of water and power less than at Lockville. It may be estimated as in the following table. The pond being 7 miles long, there is no doubt that the low-season flow could be concentrated into 12 hours, so that the power given in the table would be doubled with a small diminution of head. Although this place is not quite so conveniently located as Lockville, it is easy of access from that place, as well as from Cumnock, on the Cape Fear and Yadkin Valley railroad, and the Raleigh and Western railroad touches the river near the old Endor furnace:

TABLE OF POWER AT GORGAS DAM.

State of flow.	Drainage area.	Fall.	Flow, per second.	Horsepower available, gross.	
(See pages 54 to 59).	Sq. miles.	Feet.	Cubic feet.	1 foot fall.	7 feet fall.
Minimum	1,300	7	208	23.6	165
Minimum, low season			247	28.1	200
Low season, dry years			282	32.1	225

The ENDOR DAM, now washed away, was about 400 feet long and 4 feet high, crossing the river in the shape of a V, with a vertical face and inclined back half way across, and an inclined face and vertical back for the remaining distance. It was built of wood, and ponded the water back to the Gulf dam, a distance of 10 miles. As far as the location goes, it could be used for power, but the fall is so small that it would not be advisable. It is not necessary to consider it further.

GARDNERS SHOAL is the first power worthy of mention above Moffet's mill, 8½ miles below, and is a small shoal on the land of L. Moffet, which is entirely undeveloped. There is said to be here an available fall of 10 feet in half a mile or more. The bed and the banks of the stream are of rock, thus rendering the development of the power more feasible.

MOON'S SHOAL, one and three-fourths miles further up-stream (owned by L. T. Moon), was the site of an old gun-shop. The fall here is about 6 feet in 300 yards over rock bottom. The dam and other improvements have disappeared.

SILER'S SHOAL, one and one-half miles above Moon's, and three-fourths of a mile below the Enterprise mills, is an unimproved shoal owned by D. U. Siler, Coleridge, N. C. There is said to be an available fall here of about 20 feet, in one-fourth of a mile over good rock bottom, and the shoal is otherwise one that can be easily utilized.

THE ENTERPRISE MILLS are located on a shoal three-fourths of a mile above Siler's shoal. The cotton-mill on the northeast side of the river here operated by the Enterprise Manufacturing Company contains 4000 spindles and uses about 150 horsepower. The dam is constructed of cemented stone, 3½ feet high, 360 feet long, and backs the water three-quarters of a mile. The race is 250 yards long, and gives a head of 20 feet at the wheel, which is a Leffel special turbine 44 inches in diameter. There is also a small flour-mill operated by water from the same race. The supply of water is ample for all purposes throughout the entire year.

STOUT SHOAL.—One and one-half miles above Enterprise there is a shoal owned by Thos. Davis, having a fall of about 8 feet in 300 yards.

COX'S SHOAL, a mile and one-half above Stout's, is similar to the latter shoal, and is owned by Seth Cox, of Coleridge, N. C. There is here a natural fall of about 7 feet in 300 yards, entirely undeveloped.

The ALLEN SHOAL is located two miles above the last and one mile below Ramseur. This undeveloped property is owned by Jackson Craven. It has a fall of about 14 feet in one-half a mile over a good rock bed with banks suitable for building.

RAMSEUR.—The cotton-mill of the Columbia Manufacturing Company is located here on the northeast side of the river and contains 9916 spindles and 325 looms. The dam is of stone, 12 feet high and 425 feet long, backing the water up to the Randolph Manufacturing Company's mill. The race is 300 yards long and the working head is 15 feet. The power plant consists of a Sampson 56-inch turbine-wheel, developing 180 horsepower, and a Corliss engine of 200 horsepower.

It is estimated that 250 horsepower is required to run the mill, so that steam has to be used all the time.

FRANKLINVILLE.—Between 2½ and 3 miles above Ramseur is the mill of the Randolph Manufacturing Company, which contains 3500 spindles and 112 sheeting looms, requiring 125 horsepower. The dam is of stone, 8 feet high and about 400 feet long. The race is 100 yards long and carries the water to two turbine-wheels, one of 30 inches, the other of 33 inches diameter. These are said to develop 143 horsepower under the head of 12 feet. The auxiliary steam-plant is of 125 horsepower, but this is used for only three months in the year.

Half a mile up the stream from the above is the mill of the FRANKLINVILLE MANUFACTURING COMPANY, containing 2500 spindles and 40 bag looms, and using about 90 horsepower from the water for nine months in the year. During the remaining three months steam and waterpower combined are used. The dam is of stone, 5 feet high and 400 feet long. The race is between 450 and 500 yards long and the fall at the wheel is 18½ feet. The power is developed by a special 40-inch turbine-wheel, generating 112 horsepower. There is also a grist-mill and cotton-gin drawing water from the same race and using about 30 horsepower.

CEDAR FALLS.—About two miles above the last-mentioned is the cotton-mill of the Cedar Falls Manufacturing Company, containing 3936 spindles, operated entirely by waterpower. The horsepower required is developed by a turbine working under a head of 25 feet and having an estimated capacity of 125 horsepower, given by three dams between islands, one of 10 feet high and 150 feet long, and two of 7 feet high and 280 feet long each, through a race about one-half mile in length. There is plenty of water to run the mill all the year.

About one mile above this site there is an undeveloped shoal where the available fall is said to be 12 to 15 feet.

CENTRAL FALLS.—Two miles above the last-mentioned site is the Central Falls mill of the Worth Manufacturing Company. The dam here is of wood, 9 feet high and 325 feet long, and backs the water up to the dam of the upper mill, a distance of three miles. The wheels are two in number, one 61-inch, the other 30-inch, developing about 150 horsepower. About 50 horsepower additional is developed by the supplementary steam-plant, which is used here all the time.

WORTHVILLE.—Three miles above Central Falls is the site of the upper mill of the same company. The dam here is of stone, 17 feet high and 250 feet long. There is no race, the two special design 33-inch turbine-wheels, which develop about 175 horsepower, being located directly at the dam, which backs the water for 1½ miles. There is also a steam-plant capable of developing about 200 horsepower, but there is enough water to run by waterpower alone except in the very dry seasons. The two mills at Worthville and Central Falls together contain 10,000 spindles and 328 looms.

NAOMI FALLS.—Four miles further up the stream from Worthville is the mill of the Naomi Falls Manufacturing Company, of Randleman, N. C. This mill was built in 1880, and contains 5000 spindles and 298 looms for the manufacture of cotton cloth and cotton bags. The dam here is of wood and stone, 13 feet high and 300 feet long, backing the water about one-half mile. There is no race, the water going at the dam directly to the wheels, of which there are two, each 48 inches in diameter, the two developing about 130 horsepower. This is supplemented at all times by 50 horsepower (and more in dryest seasons) from the 150 horsepower engine which is maintained for this purpose.

RANDLEMAN.—One mile above Naomi Falls and in the town of Randleman are located the two mills of the Randleman Manufacturing Company, the two containing 5000 spindles and 270 looms, both mills being run by water from the same race. The dam here is of stone, 12 feet high and 275 feet long, and backs the water 2½ miles without throwing the river out of its banks. The race is about 500 feet long and the working head is 12 feet, developing 175 horsepower, given by four turbines, three of 44 inches diameter, one of 40 inches. For about six months of the year there is enough water to run the mill to its full capacity by the use of waterpower alone. During the dry season this is supplemented by steam-power.

There is said to be a shoal called the Island Ford shoal, located 2 miles above Randleman, and said to have a fall of 10 or 12 feet.

WALKER'S MILL.—Four miles above Randleman is Walker's gristmill, owned by S. Bostick & Son, Randleman, N. C. This mill contains two sets of corn stones, one of wheat burrs, a fan-mill and a smutter. The fall here is 10 feet from an 8-foot stone dam, 300 feet long, which backs the water about 1½ miles. The race is 110 yards long and carries the water to two 20-inch turbines. No estimates of the amount of power used or available at any of these grist-mills could be obtained, the estimate of the amount of power used in running a set of stones varying from 8 to 12 horsepower, and the other machinery in proportion. According to the statements of the millers, however, there seems to be plenty of water to run all the machinery in the mills at the same time, if so desired, during the very dry seasons.

COLTRAIN'S GRIST-MILL is three miles above Walker's and contains the same machinery as the latter. It is driven by four turbines, three of 18 inches diameter, one of 10 inches. The fall here is 10 feet, obtained by an 8-foot masonry dam through a race 100 yards long. The dam is 200 feet long and backs the water 1½ miles.

FREEMON'S GRIST-MILL is five miles above the last one. This mill was built in 1876 for a woolen-mill, and was run as such for some time, but the woolen machinery has been sold, and the building, two stories high, built of stone and brick, is used as a grist-mill. Three sets of stones are run, two corn and one wheat, and a smutter, each driven by a separate turbine, three of 12 horsepower for the stones and one of 8 horsepower for the smutter. The dam is of masonry, 12 feet high and 130 feet long and there is no race. The property is in good condition. The pond is one and one-half miles long and of an average width of 75 feet. There is said to be too little water here for running all the machinery at the same time unless the river is a little full.

The OAKDALE MANUFACTURING COMPANY'S COTTON-MILL, the next power site, is located five miles above Freemon's mill and four miles below Jamestown. The mill, which contains 3320 spindles, was built in 1889, but there has been a mill on the site since 1866. The fall here is 25 feet, obtained by means of a 20-foot wooden dam 260 feet long. The race is 250 feet long, and carries the water to a 44-inch Leffel special turbine, developing, it is claimed, 190 horsepower when the water supply is ample. The dam backs the water one mile with an average width of pond of 100 feet. There is a steam-plant of 250 horsepower capacity which is used to supplement the water in dry seasons.

The powers above this point are too small to be of any practical value; and the only one known to be now in use is that at Smith and Ragsdale's bone-mill, about one mile above the Southern railroad crossing near Jamestown, and here probably not more than six horsepower is developed with a four-foot fall during ordinary stages of flow.

SUMMARY OF POWER OF DEEP RIVER.

[N. B.—The powers given in this table may, in most cases, be increased to a large extent, and perhaps doubled, if the mills are run only 12 hours and the water drawn down in the ponds at night.]

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross.[1]			Utilized.		Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length.	Minimum.	Minimum low season	Low season, dry year.	Horsepower, net.	Fall.	
	Miles.	Sq. miles.	In.	In.	In.	In.	In.	Feet.	Feet.					Feet.	
Lockville, lower dam	2.0	1,350	12	12	11	11	46	24.0	2,000	590	700	800	......	......	Dam 11 feet.
Lockville, upper dam	2.5	1,350	12	12	11	11	46	16.0	....	390	470	525	......	......	Dam 16 feet, formerly.
Gorgas	5.0	1,300	12	12	11	11	46	7.0	....	165	200	225	......	......	Dam 7 feet, formerly.
Gulf	21.7	1,047	12	12	11	11	46	10.0	....	178	220	250	40	10.0	Dam 10 feet.
Carbonton dam	27.7	1,010	12	12	11	11	46	10.0	....	170	200	235	35	10.0	Dam 10 feet.
Glenns mills	40.2	814	12	12	11	11	46	19.0	....	265	315	361	80±	19.0	Dam 7 feet.
Prosperity mill	47.0	784	12	12	11	11	46	8.0	....	125	155	180	30	8.0	Dam 8 feet.
Big falls	50.0	746	12	12	11	11	46	18±	2,000	210	250	285	0	......	
Ritter's falls (unimproved)	51.5	....	12	12	11	11	46	....	....	......	......	......	......	......	Fall said to be 10 feet.
Howard & Moffett's mill	53.0	665	12	12	11	11	46	8.5	....	47	60	70	40	8.5	Dam 7 feet.
Unimproved powers	....	....	12	12	11	11	46	....	....	......	......	......	......	......	
Enterprise factory	63.0	453	12	12	11	11	46	20.0	....	......	......	......	150?	20.0	Dam 3½ feet.
Unimproved sites	....	440±	12	12	11	11	46	....	....	......	......	......	......	......	
Columbia Manufacturing Co.	69.0	420±	12	12	11	11	46	15.0	....	......	......	......	250	15.0	Dam 12 feet; steam-power.
Randolph Manufacturing Co.	71.0	408	12	12	11	11	46	12.0	....	......	......	......	125	12.0	Dam 8 feet; steam-power.
Franklinville Manufacturing Co.	71.5	408	12	12	11	11	46	18.5	....	......	......	......	90	18.5	Dam 5 feet; steam-power.
Unimproved site	72.5	400±	12	12	11	11	46	15+	3,000+	......	......	......	......	......	
Cedar Falls Manufacturing Co.	73.5	341	12	12	11	11	46	25.0	....	......	......	......	125	25.0	Dam 10 feet.
Unimproved site	75.0	....	12	12	11	11	46	....	....	......	......	......	......	......	
Central Falls Manufacturing Co.	77.0	300±	12	12	11	11	46	9±	....	......	......	......	150	......	Dam 9 feet, steam-power.
Worthville	80.0	300±	12	12	11	11	46	17±	....	......	......	......	175	......	Dam 17 feet, steam-power.
Naomi Falls Manufacturing Co.	84.0	257	12	12	11	11	46	13±	....	......	......	......	130	13	Dam 13 feet, steam-power.
Randleman Manufacturing Co.	85.0	257	12	12	11	11	46	12.0	....	......	......	......	175	12	Dam 12 feet, steam-power.
Walker's grist-mill	89.0	....						10.0	....	......	......	......	......	10	8 foot dam.
Coltrain's grist-mill	92.0	....						10.0	....	......	......	......	......	10	8 foot dam.
Freemon's mill	97.0	....						12.0	....	......	......	......	......	12	12 foot dam.
Oakdale Manufacturing Co.	102.0	....						25.0	....	......	......	......	......	25	20 foot dam.

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[1] See pages 54 to 59.

TRIBUTARIES OF THE DEEP RIVER.

The tributaries of Deep river are of small consequence, and only one of them is worthy of special mention, viz. *Rocky river*, which rises in the northwestern part of Chatham county and flows southeast, joining Deep river just above Gorgas dam. The stream is utilized to a considerable extent by small saw- and grist-mills, but, like other streams in the vicinity, it is subject to great variations in flow, owing to its course lying in the slate region. The drainage area of the stream is about 205 square miles, and its length, in a straight line, about 25 miles; yet, during the dry season, the flow is not sufficient to afford more than 20 or 25 horsepower, with a fall of 20 feet. There are 12 mills on the river, with falls of from 8 to 25 feet, but some sites are still unimproved.

The other tributaries above Rocky river are utilized for small grist- and saw-mills, but are not of much importance. Some of them are nearly dry in summer.

TABLE OF UTILIZED POWER ON CAPE FEAR RIVER AND TRIBUTARIES.[1]

Name of stream.	Tributary to what.	County.	Kind of Mill.	Number of mills.	Total fall used.	Total horse-power used, net.
					Feet.	
Cape Fear river	Atlantic	Cumberland		1	10.0	15
Northeast Cape Fear	Cape Fear	Pender	Flour and grist	1	7.0	10
Do	do	do	Saw	1	7.0	20
	Northeast Cape Fear	Duplin	Flour and grist	16	144.0	158
	do	do	Saw	3	29.0	36
	do	do	Cotton-gin	2	20.0	......
South river	Cape Fear	Sampson	Flour and grist	1	7.0	8
Do	do	Pender	do	2	16.0	18
Black river	South river	Sampson	do	2	17.0	11
Do	do	do	Cotton-gin	1	9.0	6
	do	do	do	5	50.0	27
	do	do	Flour and grist	11	115.0	96
	do	do	Saw	1	......	10
All other tributaries to	Cape Fear	Bladen	Flour and grist	2	22.0	19
Do	do	do	Veneer works	1	9.5	......
Do	do	do	Cotton-gin	1	8.0	3
Do	do	Cumberland	Flour and grist	10	95.0	150
Do	do	do	Saw	4	29.0	122
Do	do	do	Cotton-gin	3	......	......
Do	do	do	Agricult'l implem'ts	1	20.0	12
Do	do	do	Cotton-factory	1	......	......
Rockfish creek	do	do	do	1	18.0	200
Little Rockfish creek	Rockfish creek	do	do	1	22.0	175
Do	do	do	do	1	9.0	60
Beaver creek	Lit. Rockfish creek	do	do	1	16.0	189
Blounts creek	Cape Fear	do	do	1	19.0	40
All other tributaries to	do	do	Woolen	2	......	......
Do	do	Harnett	Flour and grist	13	155.5	158
Do	do	do	Saw	2	21.0	35
Do	do	Wake	Flour and grist	6	99.0	62
Do	do	do	Saw	1	11.0	18
Do	do	do	Cotton-gin	4	78.0	42
Do	do	Chatham	Flour and grist	2	30.0	30
Do	do	Moore	do	11	132.0	139
Do	do	do	Saw	6	88.5	118

[1] Compiled mainly from records of the Tenth Census.

TABLE OF UTILIZED POWER ON CAPE FEAR RIVER AND TRIBUTARIES.—*Continued.*

Name of stream.	Tributary to what.	County	Kind of Mill.	Number of mills.	Total fall used. Feet.	Total horse-power used, net.
Haw river	Cape Fear	Chatham	Grist-mill	..	10.0	......
Do	do	do	Saw- and grist-mill	1	7.0	......
Do	do	do	Cotton-factory	1	16.0	125
Do	do	do	Flour and grist	1	16.0	......
Do	do	do	Cotton-gin	1	16.0	......
Do	do	do	Flour and corn	1	14.0	......
Do	do	do	Saw-mill	1	14.0	......
Do	do	do	Blacksmith-shop	1	14.0	......
Do	do	do	Cotton-factory	1	19.0	160
Do	do	do	Grist-mill	1	9.0	40
Do	do	do	Cotton-factory	1	13.0	160
Do	do	do	do	1	12.0	450
Do	do	do	do	1	14.0	136
Do	do	do	do	1	15.0	150
Do	do	do	do	1	15.0	160
Do	do	do	do	1	20.0	300
Cane creek	Haw river	Alamance	do	1	23.0	50
Alamance creek	do	do	do	1	12.5	50
Do	do	do	do	1	11.0	150
Reedy Fork	do	do	do	1	11.0	160
All other tributaries to	do	Chatham	Flour and grist	13	179.0	176
Do	do	do	Saw	3	29.0	60
Do	do	do	Wheelwrighting	1	12.0	10
Do	do	do	Cotton-gin	3	......	......
Do	do	Orange	Flour and grist	8	161.0	188
Do	do	do	Saw	6	85.0	134
Do	do	do	Cotton-gin	1	......	20
Do	do	do	Millwrighting	1	14.0	12
Do	do	Alamance	Flour and grist	17	209.0	294
Do	do	do	Saw	4	52.0	77
Do	do	do	Cotton-gin	1	11.0	6
Do	do	do	Foundry	1	15.0	28
Do	do	do	Agricult'l implem'ts.	1	16.0	8
Do	do	Guilford	Flour and grist	24	344.0	379
Do	do	do	Saw	6	79.5	93
Do	do	do	Woolen	1	12.0	......
Do	do	Randolph	Flour and grist	1	19.0	10
Do	do	Rockingham	do	6	105.0	100
Do	do	do	Saw	3	54.0	48
Deep river	Cape Fear	Chatham	Roller mill	1	......	......
Do	do	do	Flour and corn	1	10.0	40
Do	do	do	Cotton-gin			
Do	do	do	Grist and saw	1	10.0	35
Do	do	do	Cotton-gin			
Do	do	do	Flouring-mill	1	16.0	......
Do	do	Moore	Grist and saw	..	19.0	......
Do	do	do	Cotton-gin			
Do	do	do	Grist-mill	1	8.0	25
Do	do	do	do	1	8.5	40
Do	do	Randolph	Cotton-mill	1	20.0	150
Do	do	do	Flour-mill	1	20.0	......
Do	do	do	Cotton-mill	1	15.0	250
Do	do	do	do	1	12.0	125
Do	do	do	do	1	18.5	90
Do	do	do	Grist-mill	1	18.5	......
Do	do	do	Cotton-gin			
Do	do	do	Cotton-mill	1	25.0	125
Do	do	do	do	1	9.0	200
Do	do	do	do	1	17.0	175
Do	do	do	do	1	18.0	180
Do	do	do	do	1	12.0	175
Do	do	do	Grist-mill	1	10.0	......
Do	do	do	do	1	10.0	......
Do	do	do	do	1	12.0	44
Do	do	Guilford	Cotton-mill	1	25.0	190
Tributaries of	Deep river	Chatham	Flour and grist	17	225.0	253
Do	do	do	Saw	3	45.0	69
Do	do	do	Agricult'l implem'ts.	1	9.0	10
Do	do	do	Leather	1	12.0	6
Do	do	Moore	Flour and grist	8	86.0	135
Do	do	do	Saw	4	42.0	74
Do	do	Randolph	Flour and grist	23	331.0	361
Do	do	do	Woolen	1	8.5	......
Do	do	do	Saw	8	106.0	128
Do	do	Guilford	Flour and grist	5	79.0	56
Do	do	do	Woolen	1	16.0	......

TABLE OF DRAINAGE AREAS OF CAPE FEAR RIVER AND TRIBUTARIES.

	Square miles.
Cape Fear river at mouth	8,400
Northeast Cape Fear river at mouth	1,330
South river at mouth	1,430
Black river at mouth	620
Cape Fear river at Fayetteville	4,493
Cape Fear river at Jones falls	4,170
Cape Fear river at Silver run	3,660
Cape Fear river at Smileys falls	3,400
Cape Fear river at Buckhorn falls	3,200
Cape Fear river at forks	3,025
Haw river at mouth	1,675
Haw river at Bynums	1,250
Haw river at North Carolina railroad	585
Haw river at Reedy fork junction	173
New Hope river at mouth	317
Alamance creek at mouth	237
Reedy fork of Haw at mouth	281
Deep river at mouth	1,350
Deep river at Lockville	1,340
Deep river at Gorgas	1,300
Deep river at Gulf	1,047
Deep river at Carbonton	1,010
Deep river at Tyser's	814
Deep river at Franklinville	408
Deep river at Naomi Falls	257
Rocky river at mouth	205
Rockfish creek at mouth	280
Little Rockfish creek at mouth	77
Little Rockfish creek at factory	55
Lower Little river at mouth	448
Lower Little river at Manchester	329
Upper Little river at mouth	176

CHAPTER VIII.

THE YADKIN RIVER AND TRIBUTARIES.[1]

THE YADKIN RIVER.

The Yadkin river, or the Great Pee Dee as it is called below its junction with the Uharie river, takes its rise on the eastern slope of the Blue Ridge, in Caldwell and Watauga counties, North Carolina. It flows first a little north of east through Caldwell and Wilkes and between Surry and Yadkin counties, when it bends abruptly to the right, and flows a little east of south, forming the boundary between the counties of Forsyth, Davidson, Montgomery and Richmond on its left, and Yadkin, Davie, Rowan, Stanly, and Anson on its right, passing into South Carolina, and continuing in the same general direction between Marlborough and Marion counties on its left, and Chesterfield, Darlington, Williamsburg and Georgetown on its right, emptying into Winyah bay just at the town of Georgetown, after flowing for some distance through the county of the same name. Following the general course of the stream, the distance from its source to its mouth is between 275 and 300 miles, but following all its windings it is much greater—as nearly as can be estimated by measurement on the map, some 400 miles or more.

There are no towns of great importance on that part of the stream where there are any facilities for waterpower. In North Carolina there are no towns on the river with more than a few hundred inhabitants, the principal ones being Elkin, in the southwest corner of Surry county and Wilkesboro, the county-seat of Wilkes county.

The head of navigation on the river is Cheraw, South Carolina, about 149 miles above the mouth. An examination of the river between Cheraw and the mouth of the Uharie, a distance of 67 miles, has been made, and it is found practicable to render the river navigable as high as this point by locks and dams, but no appropriation has yet been made for the work, nor is it probable that there will be on account of the great cost of the undertaking and the small good to be accomplished thereby. Above the mouth of the Uharie the "Narrows" form an insurmountable obstacle to navigation, but above them, between the

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[1] By G. F. Swain and J. A. Holmes.

Southern railway bridge and Wilkesboro, the river has been surveyed, and an appropriation of $20,000 made March 3, 1879, the object being to secure a navigable depth of 2½ to 3 feet as high as the foot of Beans shoal, a distance of 64.8 miles. Additional appropriations were made during the 10 years following. Subsequently (1887) it was decided to limit the improvements to the 33 miles immediately above the Southern railway bridge. In 1892 the work was practically abandoned after the expenditure of slightly more than $100,000.[1]

The Great Pee Dee drains a total area of about 17,000 square miles, of which about 9700 lie in North Carolina and 7300 in South Carolina. The principal tributaries to the river are the Waccamaw river, from the north, draining about 1200 square miles; the Black river, from the west, draining about 1500 square miles; the Little Pee Dee river, from the north, with a drainage area of some 3000 square miles; Lynchs creek, from the west, draining about 1350 square miles; Black creek, from the west, draining about 450 square miles; Little river, from the east, draining 400 square miles; Rocky river, from the west, draining 1400 square miles; Uharie river, from the east, draining 317 square miles; the South Yadkin, from the west, draining 820 square miles; and the Ararat river, from the north, draining about 315 square miles, besides numberless smaller streams and creeks affording fine waterpower, especially in the upper part of the drainage basin.

The Great Pee Dee crosses the fall line a little above Cheraw. The fall is not so pronounced as in the case of the Tar and the Roanoke, but consists of a series of rapids extending over a number of miles, with no very great fall at any one place, or within any short distance. The drainage basin of the river below the fall line will be understood sufficiently well from the general description which has been already given of the eastern division, and of the lower parts of the Cape Fear and other rivers, while its general shape and dimensions may be seen from the accompanying map. Neither does that part of its drainage basin lying above the fall line differ in any essential particulars from that of the Cape Fear or the Roanoke, except that it reaches farther west (and into the mountains) than that of the Cape Fear. Below the great bend, where the river turns so abruptly to the south, its valley averages 50 miles wide, and at many points the river is bordered by wide and fertile bottoms, subject to overflow at times, and forming some of the best farming lands in the state; while at others the hills close in upon the river, leaving no bottoms at all, and sometimes confining the river between steep and rocky banks on each side. In one case the river flows through a ravine, confined in a very narrow channel by bold and abrupt banks for a distance of several miles, forming the noted "narrows." Above the great bend the valley is narrower (only 15 to 20 miles wide), and the divides which separate the basin of the Yadkin from those adjacent are much higher, so that the tributary streams in the vicinity have a very large fall. The level land along the stream, however, is seldom in this part of its course over a mile wide, interjected between the spurs of the parallel ranges of mountains and ridges which form the divides, and forming in places extremely picturesque little valleys, surrounded on almost all sides by mountains. Even in this part of its course the river rises above its banks in high water, although the grounds subject to overflow are not very extensive. Near Yadkinville the river passes through a gap in the mountains, and above that point its valley is flanked on the north by the Blue Ridge and on the south by the Brushy mountains, the divides having elevations of from 1500 feet upward, and from these come pouring down many mountain streams and torrents. The upper part of the valley of the Yadkin is very well wooded, and as the mountains are not bare, the streams are more constant in flow than might be expected. Between Wilkesboro and Patterson the lowlands along the river are from a few hundred yards to more than a mile in width, and exceedingly fertile. This region, known as the "Happy Valley," is one of the most picturesque and finest agricultural sections to be found in the state.

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[1] Annual Report Chief of Engineers, U. S. A., 1892, App. L, p. 1182,

The facilities for the construction of storage reservoirs are good on some of the tributaries, and on the main stream in the very upper part of its course. Below, they would, of course, be impracticable.

The products of the Yadkin valley are cotton, tobacco, corn, rice, wheat, oats, rye, clover and grasses, sorghum cane, vegetables and fruits in the lower part, and principally grain, vegetables and fruits in the upper part. Between the cool slopes of the Blue Ridge on the north and the low and hot plains of the eastern division on the south the range of production—as in the case of the Roanoke—is very large, the mountains being well adapted to grazing, the bottom lands of the valleys to the raising of cereals, grasses, vegetables, fruits and tobacco, and the low country along the lower part of the stream to the production of cotton and rice.

The river is somewhat subject to freshets, but not more so than other South Atlantic streams. They are said not to be so violent, as a rule, as on the Cape Fear, Neuse, or Tar, probably because of the character of the upper part of the basin; and, although there are no lakes to regulate the flow, the extensive woods and the mountains, well covered with soil, serve to restrain their violence. Neither are the freshets so violent as on the Roanoke, the cause in this case being, probably, the fact that the rainfall in the upper valleys of the Yadkin is perhaps, on the whole, more uniformly distributed throughout the year than on the Dan and Staunton. At any rate, the highest flood ever known at Wilkesboro occurred in September, 1878, yet the rise was only 23 feet above low water; and at Langenhour & Neason's mill the extreme high-water mark is at 22.9 feet. The floods are short, generally subsiding in from 36 to 48 hours. It is said that twenty-five years ago high floods very rarely occurred, and their frequent occurrence now is accounted for by the clearing of the hills and the removal of obstructions from the river.[1] The low grounds adjacent to the river are more frequently overflowed than formerly, and more damage is done to the crops.

The river sometimes brings down a good deal of ice, so that it cannot be ferried; still there is not very much difficulty on this account. The rise is sudden, the water sometimes rising, it is said, 2 feet in 20 minutes at Kirk's ferry (mouth of the Uharie).

The annual rainfall in the valley varies from 44 inches near the coast to 50 inches between Cheraw and the "narrows," and 44 to 50 above the latter point. The table on page 188 gives more detailed information regarding the rainfall above the important powers, and of its distribution through the year.

The following table gives the elevations of the various points on the stream, together with the distances, and declivity:

TABLE OF DECLIVITY OF YADKIN RIVER.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	Feet.	Miles.	Feet.	Feet per mile.
Mouth					
			149	65	0.44
Cheraw, South Carolina	149	65			
			20	40	2.00
Crossing of Carolina Central railroad	169	105			
			47	158	3.36
Foot of narrows gorge	216	268			
			4	91	22.75
Head of "narrows"[2]	220	354			
			36	237	6.58
Crossing of Southern railroad[3]	256	591			
			65	131	2.01
Foot of Beans shoal[4]	321	722			
			4	39	9.75
Head of Beans shoal[4]	325	761			
			53	167	3.15
Wilkesboro[4]	378	928			
			32	322	10.06
Patterson[5]	410	1,250			

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[1] Annual Report Chief of Engineers, 1879, p. 628.

[2] Capt. Jno. A. Ramsay, (p. 180).

[3] Line of special levels by U. S. and N. C. Geol. Surveys.

[4] Report of Chief of Engineers, 1879, p. 626.

[5] The elevation at Patterson was given in 1880, though the kindness of Maj. C. S. Dwight, chief engineer Chester and Lenoir railroad, and to L. C. Jones, Esq., at that time chief engineer and superintendent of the Cape Fear and Yadkin Valley railroad.

The flow of the river has been measured in 1896, 1897 and 1898 by the Geological Survey near Salisbury, where the drainage area is given as 3399 square miles, and at Norwood, where the drainage area is given as 4614 square miles.

At Salisbury, the lowest flow measured was in August, 1896, when the quantity discharged was 1293 cubic feet per second, or 0.38 cubic feet per second per square mile, while the maximum flow measured was 11,837 cubic feet per second, or 3.5 cubic feet per second per square mile. The flow of 1293 cubic feet per second was, however, not the minimum by any means.

At Norwood, the smallest flow measured was 1508 cubic feet per second, or 0.33 cubic feet per second per square mile, while the maximum measured was 11,710, or less than near Salisbury.

These measurements have not been continued long enough to serve as a reliable basis for computing the minimum or low-season flow, and we have been obliged to resort to the usual estimates. We have seen that measurements on the Cape Fear river have given the flow as low as 424 cubic feet per second where the drainage area was about 4500 square miles, or less than 0.1 cubic foot per second per square mile, and it is probable that the Yadkin at times reaches a figure below the smallest mentioned above, though it must be admitted that the conditions of both soil and forest covering in the Yadkin basin are more favorable for uniformity of flow than is the case in the Cape Fear basin.

One of the greatest drawbacks to the utilization of waterpower on the Yadkin is the inaccessibility of the river over considerable portions of its course; but there has been much improvement in this direction during the past few years. It is crossed in its waterpower portions by only three railroad lines—the Carolina Central, the Southern, and the Mocksville division of the Southern. The Salisbury-Norwood branch of the Southern passes along the entire length within from 4 miles (at Norwood) to 12 miles of the river; and the Wilkesboro division of the same road follows the north bank of the Yadkin from the eastern part of Surry county to Wilkesboro. The Atlantic Coast Line Railroad Company has recently surveyed a route up the Pee Dee and Yadkin from Wadesboro to Salisbury which passes through the gorge of the "Narrows" and near other promising but undeveloped waterpowers. We may now proceed to describe the river more in detail, with its various waterpowers, in order, commencing at its mouth.

WATERPOWER ON THE YADKIN RIVER.

Below Cheraw there is, of course, no power, and the river has the same character as the Cape Fear below Fayetteville, so it need not here be described.

Between Cheraw and the crossing of the Carolina Central railroad, a distance of 20 miles, the fall is at the rate of about 2 feet per mile,[1] and the width of the river 350 to 500 feet. There are 11 shoals in this distance, but none of much importance, and none in themselves available for power, although, by the construction of long canals, power might be secured. Such a plan would not, however, be advisable. At Cheraw the river is only 350 feet wide, and the greatest rise in freshets is 34 feet. The bed is generally rock and bowlders.

Between the Carolina Central railroad and the mouth of the Uharie river there are four prominent shoals which may be considered available for waterpowers; and between these are a number of smaller shoals which need not be mentioned in this connection.[2] The total distance is about 47 miles, and the total fall in the river between the two points about 158 feet.

BLUITTS FALLS.—The first of these shoals is about 12 miles above the state line, and 4.5 miles above the railroad. This shoal is about 1000 feet long, and has an estimated fall of 8 or 9 feet in this distance. The main body of the stream at this point is filled up with large rocks, and the water descends in a succession of plunges. There is a channel on the right side which is almost clear, and has a fairly uniform slope. A nine-foot dam is considered practicable here, and this would develop a considerable power. Some years ago this shoal was used by a grist-mill and cotton-gin on the Richmond county side; a primitive wing-dam giving a fall of 6.5 feet. These have since disappeared. In developing this power one may reasonably expect 250 horsepower for each foot of fall during ordinary dry seasons, and a considerably larger horsepower during 8 or 9 months of each year (see p. 188).

GRASSY ISLAND SHOAL, which begins about 13 miles above the state line, and 5.3 miles above the railroad, is the next above Bluitts, and has an estimated fall of 35 or 36 feet in a distance of 4½ miles. The river at this place is at least half a mile wide, with an average depth of only about 8 inches, and is full of small rocky islands, covered with a green weed. There are seventeen ledges which cross the river along the shoal, and at each there is a fall of about 6 inches; and in addition to these there are nine fish dams, with an average fall of 15 inches at each. In considering the possibility of rendering this portion of the river navigable, it was proposed to overcome this shoal by four locks and dams of nine feet lift each, 36 feet in all.[1] The banks of the river are said to be favorable for the utilization of the power. The shoal has only been utilized thus far by a small grist-mill. In the development of this power one may reasonably expect 250 horsepower per foot of fall during ordinary dry seasons, and a much larger power during 8 or 9 months of every year (see p. 188).

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[1] Annual Report of the Chief of Engineers, 1879, p. 725. From this report, on an examination of the river between Cheraw and the mouth of the Uharie, and the report of Lieut. Taylor on the same subject in the Annual Report, Chief of Engineers, 1888, p. 964, most of the following notes on that portion of the river have been taken.

[2] Annual Report, Chief of Engineers, 1888, Appendix L 19.

Swift Island shoal, the next above and 42 miles above the state line, has an estimated fall of 18 feet in 2½ miles. There is one plunge of about 2 feet near the middle of the shoal. The upper end of this shoal is about 27 miles above Grassy Island and about 15 below the Narrows. There is a rock dam 4 to 5 feet high extending across the river in the form of a V with the apex up-stream, from which a race about one-half mile long leads to an abandoned cotton-factory on the east side of the river, while on the west side there is a grist-mill run from the same dam. These mills used only a small power, and they are reported to have been stopped by high water ten to twelve days in the year. Mills are said to have been in operation at this point for three-quarters of a century. Undoubtedly a considerable waterpower can be developed here, and it can be utilized on either or both sides of the river. The site is about 8 miles east of the Southern railway station at Albemarle, the county-seat of Stanly county. The power at this shoal may be expected to reach 155 horsepower for each foot of fall during ordinary dry seasons, and a much larger horsepower during 8 or 9 months of each year (see p. 188).

Gunsmith shoals, 57.5 miles above the state line and about 13 miles above the upper end of Swift Island shoals, has a fall of 9½ feet in a little less than a half mile in length. In it there is one plunge of 2 feet and another of one foot. The general bed of the stream is full of large rocks, there being no particular channel, but there are narrow passages between the rocks where small boats can pass. This shoal is just below the mouth of Uharie river, and is 8 or 9 miles east of Albemarle. There is a wing-dam on the east side of the river, and a grist-mill using a fall of 4 or 5 feet.

The Narrows of the Yadkin.—The section of the river for five miles above the mouth of the Uharie is quite different in character from that both below and above this region. Over the shoals just described and those to be described further on as occurring higher up the stream, the bed of the river spreads out to a width of from 1000 to 1500 feet, and at Grassy Island is not less than one-half mile wide. But in the three and one-half miles under consideration the river runs

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[1] Annual Report of the Chief of Engineers, 1879, p. 725.

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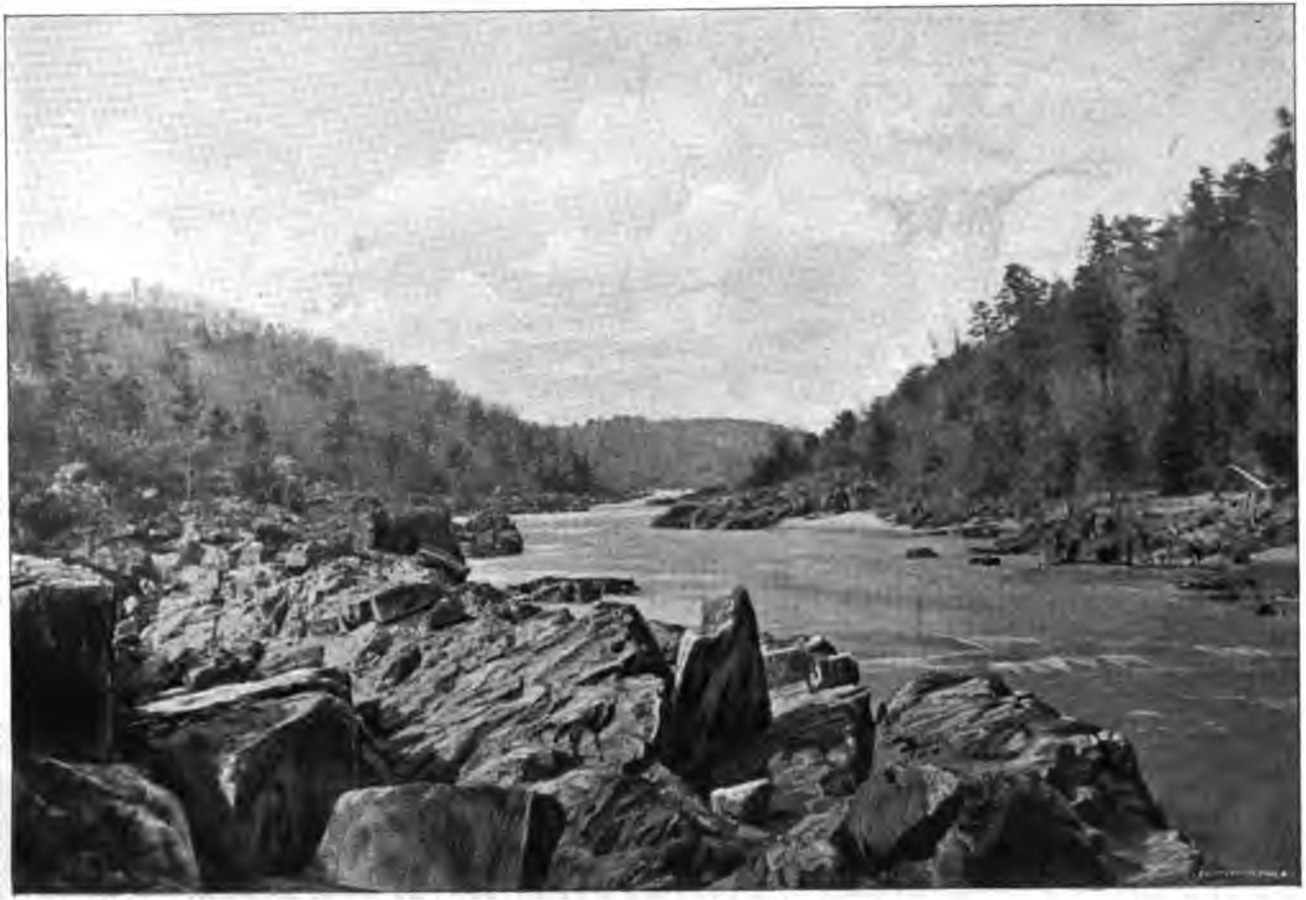

THE NARROWS OF THE YADKIN RIVER, LOOKING UP THE STREAM through a deep, narrow gorge, and here, perhaps, the most remarkable waterpower in the state occurs at the "Narrows of the Yadkin." At the upper end, before reaching the Narrows, the river is nearly or quite 1000 feet wide, from which it suddenly contracts, entering a narrow ravine between the hills, which rise abruptly on either side with rocky and almost perpendicular banks, and through which it pours with great violence, preserving for a distance of about a mile an average width of not over 150 feet, while in some places the width is only 60 feet. No description can do justice to this place, which is one of the most wonderful spots that can be found in the south (Plate VI).

In the Narrows proper—the mile referred to above—the river has cut out its channel in the solid rock, the banks being almost perpendicular for a height of 5 to 15 feet above low water, when they retreat nearly horizontally, but so very broken and rough that it is difficult and tiresome to make one's way along, for a distance of about 100 to 150 yards from the immediate channel, where the hills rise very steeply. Thus the average width of the ravine is in the neighborhood of 250 yards, or rather less, while the channel of the river, through which its whole volume pours in low water, is 75 feet or less in width, while the water is said to be very deep. The stream overflows its banks in freshets and fills the whole ravine, although it is very seldom that it covers all the projecting rocks. Below the Narrows proper the stream expands to a width of 150 to 300 feet, and flows as a rapid current for the succeeding 2½ or 3 miles, through a narrow gorge, the banks on either side being very steep and rocky all the way, except at one or two places where small lateral valleys diverge, and where there is a place to put a single mill.

Some 2 miles below the Narrows, but still within the gorge, are the rapids known as the "Little falls," and half a mile below these are the rapids known as "Big falls." Just below the latter comes a long and narrow stretch called the "Lake," the river being still confined between rocky and steep banks, the fall being very small, the width of the stream only about 100 to 200 feet, and the depth very great. The banks slope down at a steep angle straightway into the river, and are of rock and forest-covered. At the lower end of the "Lake," which is between a quarter and a half-mile long, the river widens at a place called Terrapin Hole, and thence down to the mouth of the Uharie, a distance of about a mile; it is interspersed with rocks and islands, with banks ten to twenty feet high on each side, and behind them flat lands for several hundred yards.

The total fall in the river from the top of the falls at the head of the Narrows to the mouth of the Uharie river is 91 feet, and the distribution of this fall, as shown by the measurements made by Capt. John A. Ramsay of Salisbury, is as follows:

TABLE OF FALL AND DISTANCES IN THE NARROWS GORGE.

From	To	Approximate distance, miles.	Fall, feet.
Top of Narrows[1]	Bottom of main Narrows[1]	1.0	37.0
Bottom of main Narrows	Foot of Hamilton's fishery	1.0	8.7
Foot of Hamilton's fishery	Above Harris' mill	1.0	4.4
Above Harris' mill	Top of Little falls	0.5	9.0
Top of Little falls	Bottom of Little falls	0.2	7.3
Bottom of Little falls	Top of Big falls	0.3	8.4
Top of Big falls	Bottom of Big falls	0.2	7.8
Bottom of Big falls	Kirk's old ferry (now Lowder's) and mouth of Uharie river	1.3	8.9

If a 5-foot dam were constructed across the river just above the fall at the head of the Narrows and the water carried along the left or east bank in a canal or flume, allowing a fall of one foot in the canal, this would give a fall of about 41 feet at the lower end of the canal, less than a mile in length.

From the foot of the Narrows to the mouth of the Uharie river there is a total fall of 54.5 feet, the distribution of which is shown in the table given above. As indicated there, of the fall between the foot of the Narrows and the top of "Little falls," 9 feet of 22.5 feet, is within half a mile or less of the latter place. This 9 feet, added to the 23.5 feet between the top of the Little falls rapids and the bottom of the Big falls rapids, gives a total fall of 32 feet in a distance of little over a mile.

According to what has been said, it will be seen that this magnificent power is, unfortunately, not easily available. A dam could be built on the river above the Narrows and the water carried along by the flume, the power-house being located on the rocks; but while such a use of the power would be perfectly practicable no one would think of locating a large establishment in a gorge of the mountains in such an inaccessible place and on the rocky banks of the river, where it is liable to overflow in time of high water. A canal could not be cut along the Narrows except at very large cost; neither could it be carried around the hills, except with great difficulty. However, the development of this power is regarded as being entirely feasible; and indeed plans for such development are already under way.

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[1] Starting on the right or west bank of the river at the top of the little fall or shoal, 690 feet above the mouth of Palmers creek and extending down-stream for a distance of 5800 feet, to the lower end of the Narrows proper, where the surface of the water becomes fairly smooth and where the right bank turns southwards.

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BETWEEN

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by C. E. Cooke a

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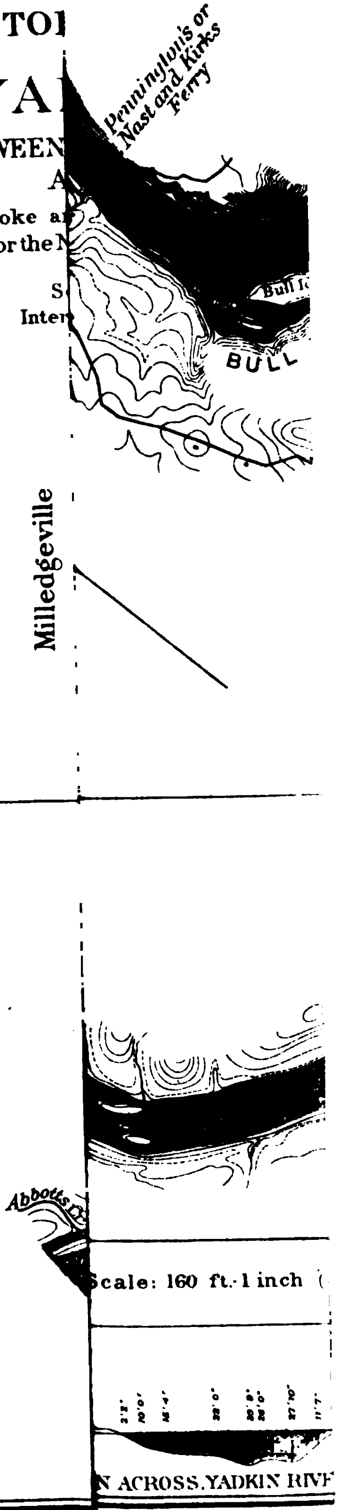

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Below the Narrows proper there is no horizontal bank, as there is at the former place; but the channel is wider and the banks slope down to the water's edge, so that to canal or even to flume around this part of the fall would be difficult. There are a few places where lateral ravines make down to the river, at which the banks are not so abrupt, and where there is room for a single mill or power-house and, in fact, one small grist-mill was formerly even situated in this part of the Narrows, near Little falls, being run from a small wing-dam, and using a fall of 6 or 7 feet; but there are no facilities for the location of a manufacturing town, or even of a large mill. There are no low grounds between the head of the Narrows and the mouth of the Uharie. The rock in the Narrows is a solid altered conglomerate, probably volcanic, very hard, almost impossible to fracture, and difficult to blast. Some power might be obtained by damming the river at the Terrapin Hole and throwing the water up over the Little falls, or at Little falls itself a mill could be established; but a very small portion of the total power at this place is practically available, except by transmitting it, by electricity or some other means, by land suited for the erecting of large manufacturing establishments.

As shown by the accompanying topographic map (Plate VII, p. 182) of this part of the Yadkin river, a dam 100 feet high across the lower end of the Narrows gorge (at A-B on the map) would back water but little above the upper end of the gorge, and would flood hardly ten acres of cultivatable land. The bed and banks of the river are of solid rock, and there is also at hand an ample supply of stone suitable for the construction of such a dam. Immediately below this point the river basin widens out to such an extent that there would be but little loss of power from high water. From this point the power could be transmitted by electricity to suitable points on the Salisbury and Norwood branch of the Southern railroad, about five miles distant, where manufacturing establishments could be located or the power could be transmitted to Lexington, Salisbury, Concord or Charlotte, the distance to the last named being about 50, and to the other three places, about 30 miles in each case.

The theoretically available power is estimated in the following table:

TABLE OF POWER AT THE NARROWS OF THE YADKIN.[1]

State of flow.	Drainage area.	Flow per second.	Horsepower available, gross.			
			1 foot fall.	Narrows proper. 37 feet.	Big and Little falls. 32 feet.	Total fall. 91 feet.
(See pages 54 to 59.)	Square miles.	Cubic feet.				
Minimum	3,940	866	98.4	3,641	3,149	8,954
Minimum average for the low season		1,100	125.0	4,625	4,000	11,375
Average for the low season of average dry years.		1,250	142.0	5,254	4,554	12,922

Above the Narrows, and between this place and the Southern railway crossing near Salisbury, there are 6 important shoals and a number of intervening smaller ones.[2] The general width of the river in this portion of its course is from 600 to 1000 feet. The banks have a general height of about 10 feet above average winter water, and the level lands generally extend back from 200 yards to one-half mile from the river banks; but at all the more important shoals the banks are quite precipitous, and there are reported to be a number of excellent mill sites, some of which are partially improved.

BULL ISLAND SHOAL, the first above the Narrows, has a total fall, estimated by Lieut. Taylor at 37 feet in a length of nearly 2 miles, beginning about one-half mile below Pennington's ferry and ending 1 to 2 miles above the Narrows. Capt. Ramsay's measurements, however, show a fall of 29 feet in Bull Island shoals proper, with considerable falls both above and below, as will be seen from the accompanying map (Plate VII). The bed of the stream has a nearly uniform slope of 10 feet to the mile, and, in addition, two plunges, one of about 8 and the other of about 10 feet near the lower end. At the lower end of the shoal the river spreads out to a width of one-half mile and is considerably divided into channels by islands. The drainage area above this place is about 3900 square miles, and the flow, as well as the power available per foot fall, may be estimated the same as for the Narrows.

The PENNINGTON SHOAL, as it may be called for convenience, is the second important shoal above the Narrows, lying between Nast and

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[1] For measurements of the flow of the Yadkin river see pp. 305 and 309.

[2] The notes concerning these shoals are taken in part from the report of Lieut. Taylor Annual Report, Chief of Engineers, 1888. App. L 19.

Kirks ferry and Milledgeville. It has a total fall, according to Capt. Ramsay's measurement, of 74 feet in a distance of 4½ miles. Along the entire shoal the river is spread out over a width of from 1200 to 1500 feet, the bottom being of solid ledges of rock crossing the bed of the stream at considerable angles. As shown by the accompanying river map (Plate VII), while the fall is somewhat concentrated at minor shoals, yet these are fairly well distributed throughout this distance. The flow and the power per foot fall may be estimated as but little below that given on page 188 for the Narrows.

There are two grist-mills located on this shoal, on the right or southwest bank of the river; the lower, Nast and Kirk's mill at Pennington's ferry, has a race about 2000 feet long and the fall at the mill is about 7 feet. Hall's mill, about 1½ miles above, has a race about one-half mile long and a fall of about 10 feet at the mill. In both cases the water is turned into the race by a short, low and rough wing-dam of stone loosely piled.

The MILLEDGEVILLE SHOAL, the third of importance above the Narrows, has a fall of 14 feet in a distance of about 0.7 of a mile, there being one plunge of about 6 feet near the bottom of the shoal. It is situated about 6½ miles above the Narrows, a short distance below Stokes ferry and 4 or 5 miles east of the Southern railway at New London. This shoal is utilized to a small extent as follows: The Yadkin Falls Manufacturing Company has a cotton-factory and grist-mill on the east side of the river at Milledgeville, using for both about 125 horsepower. The wing-dam on this side of the river is of rock, about 600 feet long, and gives a 10-foot fall at the factory, which contains 36 cards and 3160 spindles. On the opposite or west side of the river at this point are located a saw-mill, grist-mill, cotton-gin and wool-carding machinery, using in all about 40 horsepower, supplied with water from a small wing-dam extending from the bank across a portion of the river to an island, and which gives a fall of about 8 feet at the mill. The stoppage from high water at this point is said to be from 6 to 10 days in the year. The available power per foot fall is about the same as at the shoal below (p. 188).

MOTTS FALLS, the fourth important shoal, 2½ miles above the Milledgeville shoal, has a fall of 13½ feet in about 0.8 of a mile. There are in this distance six nearly vertical falls of from 6 inches to 2 feet each. There are several small islands scattered along the bed of the stream on this shoal, and the river is everywhere full of large rocks. There was formerly a mill located on the west bank, near the head of the shoal, but this has disappeared. From the tabular statement of the horsepower per foot fall on page 188 the power at this place can be easily calculated.

BALD MOUNTAIN SHOAL, about 2 miles further up the river, and the fifth important shoal above the Narrows, has a fall of 8½ feet in about half a mile. There are two mills located on this shoal, their wing-dams having the same general arrangement as that described at the next shoal above. Reid's mill, on the right or west side, has a fall of a little more than 6 feet, and Thair's mill on the opposite side has about the same fall. There appear to be no important tributaries to the river between the Narrows and this point, so that the power available per foot fall at the last two sites may be considered as but little less than at the Narrows (see p. 188).

FLAT SWAMP MOUNTAIN SHOAL, about 4½ miles above Bald mountain, and less than one mile below the mouth of Abbotts creek, has a natural fall of 10.2 feet in half a mile. Like the last mentioned, it is partly utilized by two grist-mills; Stafford's, on the left or east bank, which has a fall of between 6 and 7 feet, and Mauney's mill on the right bank opposite, which has a fall of 6½ feet at the lower end of a race about 100 yards long, into which the water is turned by a wing-dam several hundred feet long.

Between the mouth of Abbotts creek and the Southern railway crossing, a distance of some 10 miles, there are no shoals of importance, the total fall in this distance being, according to Capt. J. A. Ramsay's measurements, 28.3 feet.

Above the mouth of the South Yadkin river there are several small shoals, but none of any importance until Swicegood's mill is reached. This is a grist-mill having two run of stones, and the fall here is about four feet, utilized by means of a wing-dam and an undershot wheel.

The next power on the river, five miles higher up, is the grist-mill of Hege & Crott, using about four feet fall, obtained from a dam extending across the river. Of course only a very small part of the water is used.

At Hartley's mill, a saw- and grist-mill, 1½ miles further up the river, there is a shoal about four hundred feet long and of about four feet fall. The mill uses an undershot wheel, the water being turned to it by a wing-dam.

Four miles above Hartley's, at Ellis ferry, there is a small saw- and grist-mill located on a shoal about 600 feet long, and having a fall of about six feet. This mill diverts part of the water by means of a wing-dam, and home-made wooden wheels are used.

At the crossing of the Winston & Mocksville railroad, on the old site of Douthit's mill, a fall of 10 feet has recently been developed by the Fries Manufacturing and Power Company of Winston-Salem; a power-house has been constructed at this point, and the power is being transmitted to Winston-Salem, a distance of 13½ miles, and there used for lighting, street cars and various manufacturing purposes (see p. 188).

Langenhour & Neason's mill was situated 9½ miles above Ellis ferry. The shoal here has a total natural fall of 4.57 feet, and the dam was a substantial structure of wood and stone extending entirely across the river.

The Shallow Ford shoal, 6½ miles higher up the river, was the seat of an old grist-mill, now burned. There is here a natural fall of about 8 feet in one mile.

Above Shores island, and about 10 miles above the Shallow Ford shoal, ten miles below the head of Beans shoal, is another shoal with a fall of about 8 feet in 1¾ miles.

At Johnsons falls, at Donnaha station, on the Southern railroad, about five miles above the last mentioned, there is a fall of about four feet in half a mile above and below the station. Opposite the station there is a ledge of rock extending diagonally across the river, over which the water falls in a straight plunge for two feet. The banks here are low and the bottoms are quite broad and only about eight feet higher than the ordinary level of the river, with no indication of any rock on the surface.

BEAN SHOAL.—The principal shoal on this part of the river is Bean shoal, the fall in four miles being over 39 feet. The most rapid descent is at the head, being nearly 17 feet in one mile. The bed of the stream is very ragged, of stratified rock, which rises in sharp points and ridges at right angles to the course of the stream, forming in some places natural dams extending nearly across, and the channel is much obstructed and cut up with rocks and islands. In the lower part of the shoal there is a fall of about ten feet in two miles. The only part of the shoal now being utilized is near the middle portion, where is situated Martin's grist-mill on the south side of the river. Between 1820 and 1835 "The Yadkin Navigation Company did considerable work at these shoals with a view to rendering the river navigable. A dam was built at the head of the shoals and a canal was commenced along the northern side of the river. The only trace of a dam now to be seen is an abutment at the entrance of the canal. The canal was completed for a little more than a mile from the head of the shoals, and was from 15 to 45 feet wide at the bottom. Where the cliff forms one wall the minimum width was 15 feet. At 2000 feet from the head of the canal are the ruins of a guard-lock 12 feet wide. The canal walls are of earth, except along the foot of the cliffs. Here a very good retaining wall was built of stone quarried on the spot. The upper wall, 700 feet in length, was built of headers and stretchers neatly pinned with small stone, and is in good condition. The outer face has a batter of 2¾ inches to the foot rise. The inner face was left rough and covered with gravel and earth. No cement was used in its construction. The dimensions are: Height, 5 to 20 feet; top width, 2.5 feet; bottom width, about 7 feet. The lower wall, about four hundred feet in length, is of the same general character, but in some places has been torn down to obtain material for the construction of fish-dams. The canal has been filled in by the floods, and where it flows through the woods is overgrown with trees and bushes. No water flows through it."

Lime Rock shoal is about 7½ miles above the head of Bean shoals, and has a fall of 10.62 feet in 2.59 miles, over rock bottom.

Twelve miles higher up the river, and about 35 miles below Wilkesboro, is the Devil's Staircase and Long shoal, where in 1.61 miles the fall is 11.18 feet over a rock bottom.

The other shoals mentioned call for no special remark. The bed of the stream is everywhere rock, overlaid sometimes with gravel, and is most favorable to the construction of dams. Beside the shoals mentioned in the table there are many others with smaller falls, but which might equally well be used for power. As regards the amount of power available, there is no doubt that it is very large indeed, and that almost every one of these shoals might be utilized to a greater or less extent. Bean shoal would seem to offer the most excellent site in this part of the state, and it having been considered practicable to build a canal around the whole shoal it would seem to follow that the power might be utilized without much difficulty. While the estimates of power given in the table are only to be regarded as approximations, it is believed that they will serve to give some idea of the amount of power which might be obtained. But until larger establishments seek a location in this vicinity, and until the means of transportation are improved, the waterpower of the smaller tributary streams will be preferred to that of the main river, on account of the smaller cost, the (in general) safer location, and the diminished liability to stoppage by high water. When large amounts of power are wanted, however, and money is at hand to develop it, the Yadkin will, no doubt, be found to afford a large supply.

PATTERSON.—Above Wilkesboro the fall of the river continually increases, and there are some sites for power, but regarding them we could procure no detailed information. The only considerable power used is that at Patterson, Caldwell county, where Messrs. Gwyn, Harper & Co. have a cotton-mill, woolen-mill, saw- and grist-mill and cotton-gin. The cotton-mill contains 56 looms and 2288 spindles, and is run by waterpower supplemented by steam in dry seasons. The dam, of wood and stone, is 15 feet high and 300 feet long, and the fall at the factory is 25 feet, which it is claimed develops 80 horsepower by means of a turbine-wheel during eleven months of the year, the mill running 12 hours. The woolen-mill contains 4 sets of cards, 20 looms and 480 spindles, which are operated by the same waterpower supplemented by steam in dry seasons. The race is of wood, 200 yards long.

Above this the stream is rapid—a mountain stream, with little or no power utilized.

It may be remarked that there are only three or four dams extending entirely across the river, all above the Narrows.

The estimates of power given in the following table are liable to large error, and it is impossible to check them. All of the powers used seem large in comparison with the drainage areas above them, as in the case of the one at Patterson, and it may be that the streams in the upper part of the basin are fed by large springs, which render the flow comparatively constant. The estimates have been therefore made larger than in ordinary cases, and they may be found too large. It is to be remarked, however, that powers are often overstated, and that turbine-wheels are rated very high as regards efficiency. A power of 50 horsepower at Patterson, with a fall of 25 feet, would correspond to a flow at all times of 0.6 cubic foot per second per square mile, see pp. 55, 56 and 57.

SUMMARY OF POWER OF THE YADKIN RIVER.[1]

Locality.	Distance from state line.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross.[2]			Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length of shoal.	Minimum.	Minimum average for the low season.	Average for the low season of average dry years.	
	Miles	Sq.m.	In.	In.	In.	In.	In.	Feet.	Feet.				
Bluitts falls	12.0	6,650	12	12	11	13	48	9.00	1000	1,500	1,900	2,170	
Grassy Island shoal	13.0	6,624	12	12	11	13	48	36.00	4.5[3]	5,970	7,600	8,680	
Swift Island shoal	42.0	4,323	12	13	11	14	50	18.00	2.50[3]	1,942	2,476	2,796	
Gunsmith shoal	57.5	4,300	12	13	11	14	50	9.50	2,500	1,020	1,800	1,470	
Narrows	60.0	3,938	12	13	11	14	50	91.00	5[3]	8,954	11,375	12,922	
Bull Island shoal	65	3,800	12	13	11	14	50	29.00	2[3]	2,854	3,625	4,118	Undeveloped.
Penningtons shoal	67	3,900	12	13	11	14	50	74.00	4.50[1]	......	......	......	
Milledgeville shoal	70	3,500	12	13	11	14	50	14.00	0.7[3]	1,378	1,750	1,988	
Motts falls	72.3	3,400	12	13	11	14	50	13.50	0.8[3]	......	......	......	Undeveloped.
Bald Mountain shoal	73.8	3,300	12	13	11	14	50	8.50	0.5[3]	......	......	......	Do.
Flat Swamp M't. shoal	78.3	3,000	12	13	11	14	50	10.20	0.5[3]	......	......	......	Do.
Fries Mfg. & Power Co.	131.5	1,865	13	14	10	14	51	10.00	1,600	......	......	......	Rock bottom.
Langenhour & Neason's dam	138.5	1,827	13	14	10	14	51	4.57	......	220	280	325	Rock bottom.
Shallow Ford shoal	145.0	1,812	13	14	10	14	51	7.89	5,560	375	485	550	Rock & gravel bottom.
Shoal above Shore's island	155.2	1,638	13	14	10	14	51	7.73	9,662	330	430	490	Do.
Bean shoal (head)	164.7	1,521	13	14	10	14	51	39.17	4[3]	1,560	2,080	2,320	Rock bottom.
Lime Rock shoal	169.3	1,165	13	14	10	14	51	10.62	[1]2.59	325	425	490	Do.
Shoal below Rockford	174.8	1,097	13	14	10	14	51	8.38	4,500	240	320	360	Do.
Seven Island shoal	177.0	1,066	13	14	10	14	51	4.02	2,680	112	145	165	Do.
Long shoal	182.0	949	13	14	10	14	51	11.18	1.61[3]	205	335	385	Do.
Woodruff Fish-trap shoal	185.0	925	13	14	10	14	51	4.55	1,800	106	134	155	Do.
Mitchell Island shoal	186.6	925	13	14	10	14	51	4.00	2,740	90	115	135	Gravel bottom
Swan Creek shoal	196.7	739	13	14	10	14	51	5.40	3,160	100	125	145	Rock bottom.
Reeve Island shoal	206.5	540	13	14	10	14	51	3.86	2,700	50	65	75	Rock & gravel bottom.
Blair Island shoal	216.5	420	13	14	10	14	51	3.44	1,700	36	46	53	Gravel bottom

TRIBUTARIES OF THE YADKIN.

The lower tributaries of the Great Pee Dee, viz. the *Waccamaw*, the *Black* and the *Little Pee Dee* rivers, scarcely call for a detailed description. Lying entirely below the fall line, their general character will be sufficiently clear from what has been already said regarding similar streams, and regarding the eastern division, as a whole, in the introduction. The Waccamaw rises in Waccamaw lake, Columbus county, North Carolina, not over 25 miles from the Atlantic, and flows for a distance of 244 (?) miles nearly parallel to the coast, joining the Great Pee Dee at its mouth. It is navigable for light-draught steamers for 163 miles, and for boats drawing 3 feet of water up to the lake. Its waterpower and that of its tributaries, does not amount to much. The Black river, which has its sources in Kershaw and Sumter counties, South Carolina, is similar in character, and has no waterpower except a little in the upper part among the sand hills. The Little Pee Dee, which unites with the Great Pee Dee 23½ miles above its mouth, is more important. Rising in Richmond county, North Carolina, it flows in a general southerly course, as will be seen from the map, its length along its general course being about 75 miles, but much greater by the river, which is quite crooked, like all the streams in the low region near the coast. The total drainage area of the river is about 3000 square miles, and it receives one tributary larger than itself, the Lumber river, from the east and north, which drains nearly 1800 square miles. The sources of the Little Pee Dee are just about on, or a little below, the fall line, in the sand hills; and they therefore afford some power, their general character being the same as that of the sand-hill tributaries of the Cape Fear, which has been described, on page 139. Their declivities being uniform, no sites could be specified.

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[1] For measurements of flow on the Yadkin river, see pp. 305 and 309.

[2] For explanation of terms, see pages 54 to 59.

[3] Miles.

GUM SWAMP CREEK.

Gum Swamp creek will serve as an illustration of the character of these small sand-hill streams. It rises among the sand hills of Richmond county, about eight or ten miles above the Carolina Central railroad at Laurel Hill, and within a dozen miles of its source it furnishes the power to operate three small cotton-mills, as follows:

The Richmond cotton-mill, located on this stream 2 miles north of the railroad and about the same distance north of Laurel Hill, contains 2556 spindles, operated by about 90 horsepower, which is maintained all the year except that the water "gets a little low" in very long dry seasons. The dam is 12 feet high, 600 feet long; the size of the pond is 1½ miles long and one-third mile wide; the fall at the wheel is 10 feet; and here, as is true of both mills below, they run only during the day, and in dry seasons, when the water is drawn down slightly in the pond during the day, it fills up at night.

The Ida yarn-mill, 2½ miles below the Richmond mill and one-eighth mile south of the railroad, contains 3024 spindles operated by about 110 horsepower during all the year. The dam is 10 feet high, 900 feet long, producing a pond about one mile long and 300 to 400 yards wide, the race being 300 yards long and the fall at the mill 8 feet.

The Springfield cotton-mill, one and one-fourth miles below the Ida yarn-mill, contains 2304 spindles, and uses about 85 horsepower. The fall at the wheel is 7½ feet; the dam 10 feet high and 525 feet long. The pond is three-fourths of a mile long and 200 to 300 yards wide; the race 200 yards long.

The *Lumber river* has its sources higher up than those of the Little Pee Dee, in Montgomery and Moore counties, North Carolina, but reaching little, if at all, above the fall line. Its character resembles that of the Little Pee Dee, and on its upper part it probably belongs to the class of sand-hill streams. There are no mills, except saw- and grist-mills, on the main stream, or on any of its tributaries.

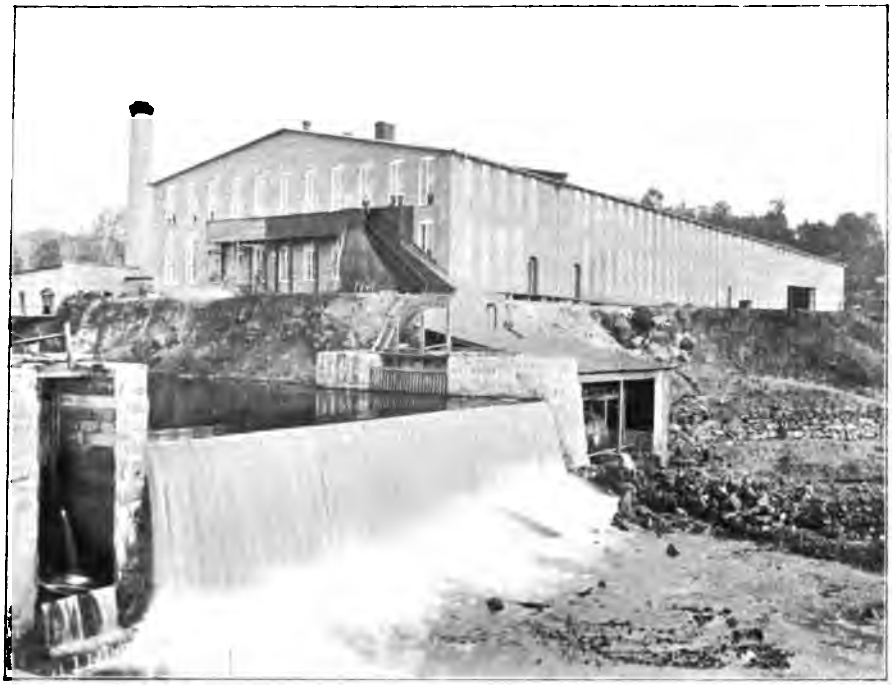
HITCHCOCKS CREEK.

The next tributary worth mentioning in North Carolina is Hitchcocks creek, although there are several streams below it which are also favorable for power. Hitchcocks creek flows entirely in Richmond county, and has a length, in a straight line, of only about 16 or 20 miles, draining an area of some 102 square miles. It receives one tributary from the south—Falling creek—worth mentioning on account of its utilized power, although it is a small stream, with a drainage area of only about 12 square miles. At the junction of these two streams is the town of Rockingham, the county-seat of Richmond county, with a population of about 1600. These streams are true sand-hill streams, so that for their general character we may refer to page 138. Falling creek, however, differs from the ordinary sand-hill streams by having a large natural fall near its mouth, which may be its crossing with the same ledge of rocks which forms the fall line. Both streams have been used to a considerable extent to drive saw- and grist-mills, as will be seen from the table of utilized power. They are principally remarkable, however, as running six cotton-mills, and they thus offer a good example of the large amount of power which may be obtained from these unpretending little sand-hill streams, as will be seen from the following statement:

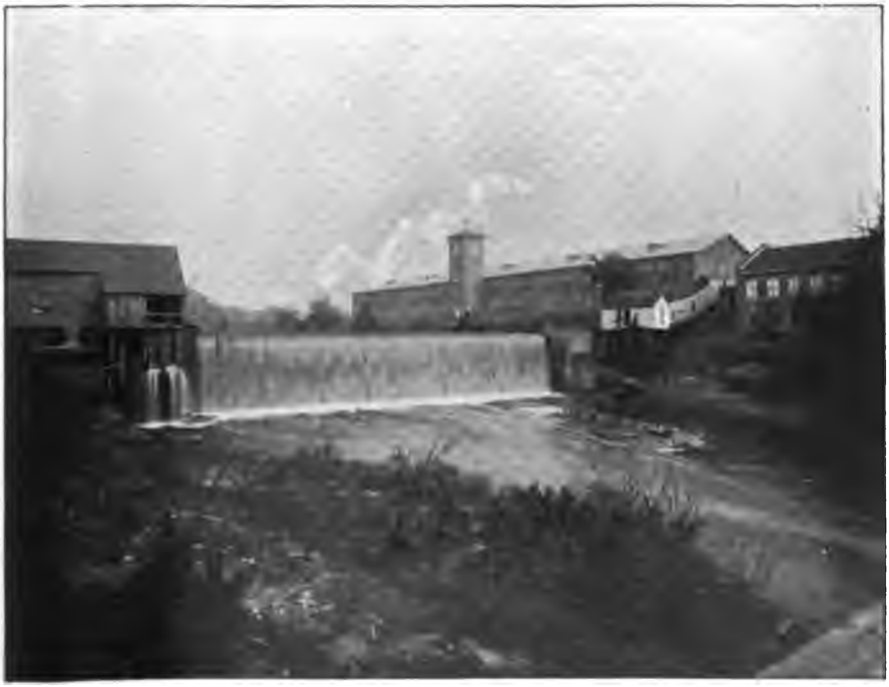
STEELE'S COTTON-MILL, containing 10,304 spindles and 300 looms, is the lowest important power on Hitchcocks creek, being 2½ miles above its mouth. The dam here is built of granite laid in cement, 16 feet high and 69 feet long, developing, it is claimed, without a race, 350 horsepower (Plate VIII).

The MIDWAY COTTON-MILL, about four miles above the mouth of the creek, on the old Aycock mill site, contains 16 cards and 6200 spindles, operated by waterpower. The dam is of wood, 13 feet high and 150 feet long. The present wheels, it is claimed, develop about 200 horsepower all the year.

The PEE DEE MANUFACTURING COMPANY'S COTTON-MILL, located two miles above the Midway mill, contains 23 cards, 300 looms and 6112 spindles. The dam is of stone and dirt, 22 feet high and 107 feet long, giving 22 feet fall, which, it is claimed, develops 300 horsepower all the year round, except during short and unusually dry seasons of dry



A STEELE'S COTTON MILL, HITCHCOCK CREEK



B—ROBERDELL COTTON MILL, HITCHCOCK CREEK

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years. The pond extends over two miles up the stream. This company has a second mill now in course of construction.

The ROBERDEL COTTON-MILL, two and one-third miles above the Pee Dee mill and three miles northeast of Rockingham, contains 24 cards, 300 looms and 6000 spindles, all operated by waterpower. The dam is of stone, 24 feet high and 170 feet long, giving a fall of 22½ feet at the mill, which is said to generate 300 horsepower all the year (Plate VIII).

The LEDBETTER MANUFACTURING COMPANY'S COTTON-MILL is located two miles above the Roberdel mill, and operates 2080 spindles and two sets of cards by water from this creek. The dam is of brick, 13 feet high and 140 feet long, giving a fall at the mill of 10 feet. The pond covers about 150 acres. About 100 horsepower is reported to be developed, of which about 75 horsepower is used all the year round, except during a few days when high water interferes. At the opposite end of the dam the company has a corn- and flour-mill.

On *Falling creek*, near its junction with Hitchcocks creek, is located the cotton-mill of the GREAT FALLS MANUFACTURING COMPANY, three-quarters of a mile above the Midway cotton-mill. This factory contains 130 looms and 4512 spindles, all operated by waterpower. This waterpower is one of considerable interest because of the comparatively large amount of power continuously developed on this small sand-hill stream with a drainage area of not more than 12 square miles. Where the dam is now located there was originally a natural fall of 25 feet over the bed rock which here underlies the sand-hill formations, and on this rock has been built a dam 18 feet high and 95 feet long (75 feet of this being brick and 20 feet wood), thus giving a fall of 43 feet. The pond has an area of 10 to 15 acres, and from this the water is carried to the wheels through an iron flume 75 feet long. The power generated in ordinary years is 150 horsepower for the entire year, the mill running only during the day, and in drier seasons the pond fills up at night and supplies a full head in the morning. In exceptionally dry years there are a few weeks during which the mill cannot run full head during more than three days of the week, but it is reported that nothing of this kind has occurred for several years. The storage of water has been carried to a greater degree of efficiency on this stream than on any other of the sand-hill streams in the state. Above the pond at the mill three earth dams have been built across the course of Falling creek and its tributary branch, thus producing three reservoirs, one of 10 to 15 acres, and two others of 20 to 30 acres each; each of these being 5 to 6 feet deep. These store up a quantity of water which is turned out as needed by the factory in dry seasons.

It is interesting to calculate the amount of water which may be depended upon from these sand-hill streams, as was done in the case of the tributaries of the Cape Fear, but the inaccuracy of the available maps renders the result liable to error to an uncertain extent. The drainage area of Hitchcocks creek above the Pee Dee factory is, according to the map, about 86 square miles. If we assume that in the low season of dry years 100 horsepower (gross) may be obtained with a fall of 22 feet during 12 hours, or 50 with the natural flow of the stream, then the flow will be about 0.23 cubic foot per second per square mile. If we assume that 250 horsepower (gross) can be obtained at ordinary stages of the stream by drawing down the water at night, then the flow will be about 0.6 cubic foot per second per square mile. For Falling creek, if we take the capacity at low seasons at 70 horsepower (gross) during 12 hours, we find the corresponding flow to be over half a cubic foot per second per square mile, or more than in the case of Hitchcocks creek; and if the capacity in ordinary seasons be taken at 150 horsepower (gross) during 12 hours, we obtain a flow of over 1 cubic foot per second per square mile. It would therefore seem that these sand-hill streams discharge from one-third to 1 cubic foot per second per square mile of drainage area, except during freshets. Compare this statement with the remarks on pages 138-40; 145 and 197.

In addition to the cotton-mills on these two small streams there are on Hitchcocks creek the following: (1) S. Gibson's saw- and grist-mill; and (2) Joe Gibson's saw-, grist- and flour-mill above Ledbetter's cotton-factory, each having a fall of about 6 feet and using 25 to 30 horsepower; (3) Ledbetter's corn- and flour-mill opposite the cotton-factory, and using a small power from the same pond with a fall of 10 feet; (4) a cotton-gin and dynamo-house opposite the Roberdel cotton-mill, using 25 horsepower; (6) a cotton-gin and grist-mill opposite the Midway cotton-mill. And near the mouth of Hitchcocks creek is the old Wall mill, not now used. On Falling creek there is now being operated but one small grist-mill in addition to the Great Falls cotton-factory, though there are two other abandoned sites. The fall of Hitchcocks creek from the foot of the Great Falls dam, on Falling creek, to the Pee Dee, a distance of 5¼ miles, is 41 feet, or about 8 feet to the mile. The pond of the Great Falls factory is about 187 feet above tide, and the mouth of the creek 103 feet. The fall is said to be equally great for several miles above Rockingham.

The tributaries to the Pee Dee from Anson county are not of much value for waterpower, as they appear to lie above the sand-hill belt, and are said to be very variable in flow. They are used only for small grist- and saw-mills, which often have to stop in dry weather.

LITTLE RIVER.

Little river, which rises in the southern part of Randolph county and flows south through Montgomery and into Richmond, joining the Pee Dee above Grassy Island shoal, is the next tributary worthy of mention, although its waterpower is not of much importance. The length of the stream is about 40 miles in a straight line, and it drains an area of about 400 square miles. None of its tributaries are of any consequence. It passes within a mile or so of Troy, the county-seat of Montgomery county, but there are no large towns directly on its course. Its fall is not large, and its flow is said to be very variable—very much more so than that of the sand-hill streams just discussed—and it is much more subject to freshets. There are only a few small saw- and grist-mills on the stream, and although it was said that there are some sites for power, especially on its upper parts, none of them are of value. The mills in use have 2 or 3 pair of stones and falls of from 6 to 10 feet, generally with a dam of about the same height. The flow of the stream is estimated at not over 50 cubic feet per second at a minimum, and 90 or 100 during the low season of *ordinary* years. The rainfall is about 46 inches, 12 in each season, except autumn.

ROCKY RIVER.

The next important tributary is Rocky river, which rises in the southern part of Iredell county, flows in a general southeasterly direction, making, however, several abrupt bends, and passing through Mecklenburg and Cabarrus counties, and then between Stanly on the north and Union and Anson on the south, its total length along its general course being about 75 miles, and its drainage area 1405 square miles. The stream receives a number of considerable tributaries, viz. from the south and west, Lanes creek (140 square miles), Richardsons creek (199 square miles), and other smaller ones; and from the north, Long creek (158 square miles), Irish Buffalo creek, Coddle creek and others. There are no towns of importance on the stream. As the drainage basin lies entirely above the fall line, the stream offers some power. The bed is rock, and in freshets the stream often rises over its banks. The power utilized is for small saw- and grist-mills and a cotton-factory. The grist-mills have generally 2 run of stones, which they can run almost all the time, although the flow of the stream is said to be quite variable. The cotton-factory, which is located not far from Concord, uses probably not over 25 horsepower with a fall of 13 feet, and can run all the time. No particular sites on the river were visited, none having been brought to our notice. The information which has been collected is very meager, but it seems probable that there is not very much power on the stream.

The flow at its mouth is estimated at between 400 and 500 cubic feet per second during the low season of ordinary years. The rainfall is about 50 inches.

UHARIE RIVER.

The Uharie river, which enters the Yadkin in Montgomery county just below the Narrows, rises in the northwestern part of Randolph county, and pursues a course nearly due south through that county and Montgomery, its length in a straight line being about 37 miles, and its drainage area 317 square miles. It passes by no important towns, and has no large tributaries. Its waterpower is not considered valuable, and is only used for country saw- and grist-mills, having generally 2 run of stones. The bed is rock, and the banks generally tolerably high on the lower part, though the low grounds are more extensive on the upper parts. There are no falls on the stream, and all the power has to be obtained by damming. The stream is, on the whole, rather sluggish, having a small fall, and crossing the ledges of rock at small angles, as has been noticed when speaking of the Narrows of the Yadkin. Its flow is exceedingly variable—in fact, the stream is said to become nearly dry in summer—due, perhaps, to the fact that it comes out of the slaty region, which has been referred to when speaking of the Deep river. On this account its waterpower is of small value, and the mills have often to stop in summer. The lowest mill is about 6 miles from the Yadkin, below which the fall is very small. A short distance above it is an old site, now not used, but probably not of much value. The freshets are heavy and sudden, as is to be expected in the case of a stream from the slate region.

Above the Uharie there are several small streams in Rowan and Davidson counties, but they are hardly worthy of special mention, being utilized only by saw- and grist-mills, and are, as a rule sluggish, with no fall or available power of much importance.

SOUTH YADKIN RIVER.

The next important affluent is the South Yadkin river, which rises on the southern slope of the Brushy mountains, in Alexander county, and flows a little south of east through Iredell, and between Davie and Rowan counties, joining the Yadkin a little above the railroad bridge, its total length in a straight line being about 42 miles, and its drainage area 820 square miles. Two of its tributaries from the north are worth naming, viz. Hunting and Rocky creeks, which drain respectively 146 and 94 square miles. The bed of the stream is rock, overlaid in places by detritus; the banks moderately high, although overflowed in places in times of freshet; the fall considerable, and the flow more constant than in the case of any of the tributaries thus far mentioned above the sand-hill belt. The power of the stream and of its tributaries is utilized to a considerable extent by saw- and grist-mills and a few cotton-factories, as will be seen by the table of utilized power.

The first mill on the stream is 4 miles from its mouth, at South river (Foard & Lindsay's), and has a fall of 6 feet, with a dam of the same height and about 240 feet long. About 30 horsepower is utilized, but the available power is much greater. The drainage area above being about 800 square miles, the capacity may be estimated at perhaps 15 horsepower per foot fall during very dry seasons, and at 25 to 30 during the low seasons of ordinary years. This mill is sometimes troubled with backwater. The dam backs the water about 3 miles, nearly up to the foot of the next power above, Hairstons or Perkins shoal.

HAIRSTONS SHOAL is the most important one on the stream, and is some 12 miles from Salisbury, and above the mouth of Third creek. The stream has, with a dam 3½ feet high, a fall of 15 or 16 feet in a quarter of a mile, but the principal part is at the upper end, being 13 or 14 feet in 200 yards. There was at one time a race cut on the north bank to the foot of the shoal, a quarter of a mile long, and along it were a foundry, a woolen-mill, and a grist-mill. When examined (1897) there was a race 200 yards long, at the end of which is a grist-mill, with a fall of 13 feet; and there was also a saw-mill 50 yards from the dam with a fall of 12 feet. The power used is probably not over 40 horsepower. The dam, which extends entirely across the stream, is 250 feet long, 3½ feet high, built of wood some years ago at a cost of $1250, and backing the water for a mile or so, it is said. The location is an excellent one—safe, and with good facilities for canals and buildings.

This power has recently been purchased by the Cooloomee Water-power Company and it is proposed to develop it at an early date. We understand that the development plans include a dam 18 feet high, which, it is said, will back the water about 5 miles, and it is expected that 1000 horsepower will be secured. This power will be transmitted electrically to suitable localities and sold to consumers.

The Cooloomee Manufacturing Company propose, it is said, to erect a large cotton-mill near this place in the near future, to be supplied with power by the waterpower company.

By means of proper storage dams, permitting the total water-supply to be concentrated into 10 or 12 hours, the power due to the natural flow of the stream may be increased by 100 per cent or more.

Above this shoal there are no mills for a long distance, and there are no important powers. Sharpe's saw- and grist-mill, about 35 miles above the mouth of the river is reported to have a dam 100 feet long and 8 feet high, giving a fall of 14 feet, and to use about 35 horsepower in its operations. On the upper part of the stream there are small mills, but none worth mentioning in this connection.

The tributaries to the South Yadkin afford a number of very good small powers. Second, Third, Fourth and Fifth creeks, from the south, are all utilized to a greater or less extent by small mills, but are not very favorable; and Hunting, Rocky, Bear and Snow creeks, especially the two first named, from the north, are used to a considerable extent for small powers.

Hunting creek has a cotton-factory (recently burned) at Eagle mills with a fall of 18 feet and 60 horsepower, it is said, the dam being 3½ feet high, and the race 400 feet long. This stream is said to offer a number of sites not used, Mr. Thos. Holcomb's undeveloped shoal being reported as equal to that at Eagle mills. Miss Alice Campbell's grist-mill is reported as having a dam 110 feet long, 8 feet high, with a fall of 12 feet and using 25 horsepower; and Troy's saw-mill, and Nicholson's grist- and saw-mills, both lower down, are said to use 50 horsepower each. A cotton-mill was built at Nicholson's, but its operations were discontinued and its machinery sold several years ago. It is probable that the tributaries from the north all have a much greater fall than those from the south. Hunting creek drains an area of about 146 square miles, and the area above the factory is about 100. We would estimate the power at the factory at between 2 and 3 horsepower gross per foot fall during low seasons of ordinary years—nearer 3 than 2—or perhaps 40 horsepower net, with 18 feet fall and a good motor. The amount of power actually used in the factory is uncertain.

Rocky creek, with a drainage area of 94 square miles, has located on it Stimpson & Steele's cotton-factory (1152 spindles) and a grist- and saw-mill at Turnersburg, using a fall of 19 feet and about 80 horsepower during ten months, and 60 horsepower during the remaining two months. The dam is about 300 feet long and 6½ feet high. Above the cotton-mill are the following mills in about the order named, the waterpowers given being the amounts used during the average season:[1] Summers & King's grist- and saw-mills, fall of 15 feet, 75 horsepower;

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[1] Data for this statement were furnished by Mr. N. T. Summers, of Olin, N. C.

Huies' grist- and saw-mill; 12 feet fall, 35 horsepower; Jenings' grist- and saw-mill, 11 feet fall, 35 horsepower; A. G. Meyers & Co., grist and saw-mill, 12 feet fall, 20 horsepower; Williams' grist- and saw-mill, 12 feet fall, 20 horsepower; M. H. Shoemaker's grist-mill, 12 feet fall, 20 horsepower; Robert Maberry's grist- and saw-mill, 12 feet fall, 20 horsepower. A short distance above the cotton-mill at Turnersburg there is reported to be an excellent undeveloped waterpower belonging to Mr. T. M. Gill. Rocky creek is similar in character to Hunting creek.

The tributaries to the Yadkin from Forsyth, Davie, and Yadkin counties are not worthy of special mention, as they are small, and in some cases very sluggish, offering no powers of importance. In Surry and Wilkes counties we come to a number of streams which rise in the Blue Ridge and pursue a southerly course to the river, draining a country very well wooded, and having a very considerable fall. In Wilkes county there are also a few streams of this class which rise on the south, on the northern slope of the Brushy mountains, and flow nearly north. All of these streams are said to afford numerous excellent sites for power, only a few of which are at present utilized. They flow over rocky beds, with banks generally favorable for the construction of dams, and their flow is said to be not very variable. They are bordered with fertile and cultivated bottom-lands. Their drainage areas are given in the table on page 200. The mean annual rainfall over all this upper part of the Yadkin valley is about 51 inches—13 in spring, 14 in summer, 10 in autumn, and 14 in winter. As regards the flow of the streams, detailed estimates are not presented, because they are liable to be too far in error. According to all the information which could be obtained regarding power utilized, the flow must be large compared with other streams of similar drainage area thus far considered. We would be inclined, however, to estimate the average flow during the low season of ordinary years at between 0.20 and 0.35 cubic foot per second per square mile of drainage area, varying between these figures for drainage areas between 30 and 300 square miles in area.

The first of these streams met with is the *Little Yadkin*, which rises among the Sauratown mountains in Stokes county and flows in a southwesterly course, entering the Yadkin river near the northwest corner of Forsyth county. No important powers are reported on this stream.

THE ARARAT RIVER.

The Ararat river, the next and largest of these upper tributaries, rises among the spurs of the Blue Ridge mountains in Patrick county, Virginia, and flowing in a general southerly course enters the Yadkin some ten miles above the mouth of the Little Yadkin. It drains an area of 315 square miles, of which something over two-thirds is forest-covered, and the soil of which, formed of granitic and gneissic rocks, is generally open or porous. The fall in the stream which descends from the slopes of the Blue Ridge to the Yadkin in a distance not greater than 40 miles, is considerable, and there are reported to be a number of good powers along its course. Above Mt. Airy are a number of grist- and saw-mills using from ten to twenty-five horsepower each.

The HAMBURG COTTON-MILL, grist- and flour-mill and machine-shop are located on the Ararat about 25 miles above its mouth, one-half mile east of Mt. Airy, the small cotton-mill operating 1600 spindles. The wooden dam is ten feet high and 150 feet long, ponding the water for half a mile up the river. The fall at the mills is 14 feet, and the entire plant uses 40 horsepower all the year, the stream developing a much larger amount.

At BUCK SHOALS, some two miles below Mt. Airy, and 23 miles above the mouth of the river, is a saw- and grist-mill with a dam about 6 feet high and 200 feet long and a fall of 15 feet, only a small portion of the power being utilized. Two miles below (21 miles above the mouth of the stream), at TUMBLING ROCK, there is said to be a natural shoal of 10 feet fall.

At FLAT SHOALS (Forge mills), three miles further down and about 18 miles above the mouth of the river, there was a dam about 350 feet long and 8 feet high, which gave a fall of 24 feet, affording what is said to be an excellent power. Half-way between the Flat shoals and the mouth of the river is located the MATTHEWS grist-mill, where a 7-foot dam gives a fall of 16 feet.

On *Stewarts creek*, a tributary of the Ararat, and four miles above where it joins the latter stream, is located the LAUREL BLUFF cotton-mill, a small factory with 2500 spindles, and a grist-mill attached. There is a dam 11 feet high and 125 feet long, giving a fall at the mill of 16 feet which, it is claimed, develops 100 horsepower nearly all the time.

On *Lovills creek*, another tributary of the Ararat, is located the ALPINE woolen-mill, about 3 miles from Mt. Airy, the mill operating 20 looms and 432 spindles. There is a dam 150 feet long and 5 feet high, giving a fall of 8 feet. The mill uses 30 horsepower, the available power being estimated at much more than this amount.

ALLRED'S woolen-mill, operating 240 spindles, 4 looms, 1 set card and 1 roll card, was located on this creek, 1½ miles below the Alpine mill; but this has been burned.

Fishers river and *Mitchells river* are the other tributaries of the Yadkin in Surry county, and on both of these there are a number of small waterpowers available, but none of special value have been reported. Both rise on the slopes of the Blue Ridge and flow through a region largely forest-covered, and the supply of water is but slightly affected by the dry seasons.

Elkin creek, which flows for the greater part of its course in Wilkes county, is used at Elkin for a cotton-factory (Elkin Manufacturing Company), with a fall of 22 feet from a dam 100 feet long and 7 feet high, and using 70 horsepower during nine months and about 50 during the remaining time. The factory contains 2000 spindles and 3 sets of cards. The waterpower is supplemented by steam-power.

About one-half mile above the Elkin Manufacturing Company's mill are the ELKIN VALLEY MILLS, which consist of a grist- and flour-mill, a shoe-factory and a tannery, and which use about 65 horsepower during the larger part of the year, from a pond which has a wood dam 13 feet high and 126 feet long, giving a fall of 18 feet at the wheel. This site was, until 1894, occupied by the woolen-mill of the Chatham Manufacturing Company.

About three miles above the Elkin Valley mills is a site known as CARTERS FALLS, which is an excellent small waterpower with an exceptionally large fall in a short distance.

In Wilkes county the more important tributaries of the Yadkin, *Roaring river*, *Rock creek*, *Mulberry river*, *Reddies river*, *Lewis fork*, *Stony fork* and *Elk creek*, all rise among the spurs of the Blue Ridge and flow as rapid mountain streams through forest-covered areas; and all afford numerous small powers, large enough and constant enough to run small factories, saw-, grist- and flouring-mills. The banks of these streams being generally high, dams can be built cheaply and without danger of overflowing large tracts of fertile land; so that a large part of the total fall of these streams may thus be rendered available for power, and there seems no doubt that a large amount of power can be utilized in this region. In the case of a majority of these streams it is probable that near their junction with the Yadkin they would afford from 2 to 4 horsepower per foot fall in dry seasons, and sites can be found here and there which can be easily developed so as to have falls of 20 to 30 feet. These powers have been rendered more accessible by the construction of the Wilkesboro railroad. The climate throughout this region is remarkably healthy and salubrious.

Reddies river rises on the southeastern slopes of the Blue Ridge and after flowing for about 20 miles, following the general course of the stream, in a southeasterly course, it empties into the Yadkin river just above the town of North Wilkesboro, draining in its course through the county an area of 47 square miles.

A short distance above the mouth of the stream there is a sash, door, blind and building material factory which obtains its power from this stream. There is a shoal with a natural fall of 4.6 feet and on this is built a 9-foot dam, giving a total fall of 13.6 feet. It is said that a 40-barrel capacity roller flour-mill will soon be completed here which will also use power from this development.

The following table will give in a more connected form a view of the drainage areas of the various streams tributary to the Yadkin:

DRAINAGE AREAS OF THE TRIBUTARIES OF THE YADKIN.

Stream.	Tributary to what.	Above what place.	Drainage area.
			Sq. miles.
Waccamaw river	Yadkin-Pee Dee	Mouth	1,295
do	...do	In North Carolina	782
Black river	...do	Mouth	1,510
Little Pee Dee river	...do	...do	3,022
Do	...do	In North Carolina	1,942
Do	...do	Mouth of Lumber river.	415
Lumber river	Little Pee Dee	Mouth	1,790
Black creek	Yadkin-Pee Dee	...do	457
Jones creek	...do	...do	96
Hitchcocks creek	...do	...do	102
Do	...do	At mouth of Falling creek	86
Falling creek	Hitchcocks creek	Mouth	12
Little river	Yadkin-Pee Dee	...do	400
Browns creek	...do	...do	206
Uharie river	...do	...do	317
Rocky river	...do	...do	1,405
Do	...do	At Garmen's mills	523
Long creek	Rocky river	Mouth	158
Richardsons creek	...do	...do	199
Lanes creek	...do	...do	140
Crane creek	Yadkin	...do	108
Grants creek	...do	...do	84
South Yadkin river	...do	...do	820
Do	...do	Hairstons falls	591
Third creek	South Yadkin	Mouth	215
Fourth creek	Third creek	...do	68
Bear creek	South Yadkin	...do	40
Dutchmans creek	...do	...do	18
Hunting creek	...do	...do	146
Do	...do	Factory	100
Rocky river	...do	Mouth	94
Do.	...do	Factory	88
Second creek	South Yadkin	Mouth	108
Muddy creek	Yadkin	...do	179
Abbotts creek	...do	...do	198
Dutchmans creek	...do	...do	97
Deep creek	...do	...do	106
Little Yadkin river	...do	...do	58
Ararat river	...do	...do	315
Do	...do	Mount Airy	60
Stewarts creek	Ararat	Mouth	51
Lovills creek	...do	...do	52
Elkin creek	Yadkin	...do	63
Fishers river	...do	...do	90
Mitchells river	...do	...do	81
Roaring river	...do	...do	89
Mulberry creek	...do	...do	56
Reddies river	...do	...do	47
Cub creek	...do	...do	37
Moravian creek	...do	...do	31
Warrior creek	...do	...do	33
Buffalo creek	...do	...do	41

Table of power utilized on the Yadkin river.[1]

Name of stream.	Tributary to what.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total horsepower utilized.
Yadkin-Pee Dee river	Atlantic ocean	Richmond	Flour and grist	1	6.5	8
Do	...do	...do	Cotton-gin	1	6.5	4
Do	...do	Anson	Flour and grist	2	.....	24
Do	...do	Montgomery	...do	4	.....	49
Do	...do	...do	Cotton-mill	1	10.0	125
Do	...do	Stanly	Grist-mill	2	17.0	.....
Do	...do	...do	Saw-mill and grist-mill	1	8.0	40
Do	...do	Rowan	Grist-mill	3	16.0	.....
Do	...do	Davidson	...do	6	31.0	.....
Do	...do	...do	Saw-mill	2	10.0	.....
Do	...do	Forsyth	Electric Power Co	1	10.0	1,000
Do	...do	Yadkin	Grist-mill	1	18.0	10
Do	...do	...do	Saw-mill	2	29.0	26
Do	...do	Caldwell	Cotton-factory	1	25.0	80
Waccamaw and tributaries.	Pee Dee	Brunswick	Flour and grist	1	9.5	6
Do	...do	...do	Saw	1	9.0	12
Little Pee Dee and tributaries	...do	Columbus	Flour and grist	3	23.5	20
Do	...do	...do	Cotton-gin	3	24.0	.....
Do	...do	Robeson	Flour and grist	27	195.0	259
Do	...do	...do	Saw	10	68.0	184
Do	...do	Richmond	Ag. implements	1	5.0	6
Do	...do	...do	Flour and grist	8	6.0	74
Do	...do	...do	Saw	2	10.0	18
Gum Swamp creek	Little Pee Dee	...do	Cotton-factory	1	12.0	90
Do	...do	...do	...do	1	10.0	110
Do	...do	...do	...do	1	7.5	85
Hitchcocks creek	Yadkin	...do	...do	1	16.0	350
Do	...do	...do	...do	1	13.0	200
Do	...do	...do	...do	1	22.0	300
Do	...do	...do	...do	1	24.0	300
Do	...do	...do	...do	1	10.0	100
Do	...do	...do	Grist-mill	4	.....	.....
Do	...do	...do	Saw-mill	2	.....	.....
Do	...do	...do	Cotton-gin, power-house	1	24.0	25
Falling creek	Hitchcocks creek	...do	Cotton-factory	1	45.0	150
Do	...do	...do	Grist-mill	1	.....	.....
Little river	...do	Montgomery	Saw-mill	2	27.0	42
Do	...do	...do	Flour and grist	7	77.0	127
Rocky river and tributaries	...do	Anson	...do	3	21.0	45
Do	...do	...do	Saw	2	14.0	22
Do	...do	Stanly	Flour and grist	12	85.0	258
Do	...do	...do	Saw	4	28.0	80
Do	...do	Union	...do	1	10.0	20
Do	...do	...do	Flour and grist	8	72.0	122
Do	...do	Cabarrus	...do	20	220.0	321
Do	...do	...do	Saw	3	.....	60
Do	...do	...do	Cotton-gin	3	34.0	55
Do	...do	Mecklenburg	Flour and grist	2	38.0	27
Do	...do	Rowan	...do	6	92.0	42
South Yadkin river and tributaries	Yadkin river	...do	...do	11	124.0	148
Do	...do	Davie	...do	8	101.0	171
Do	...do	...do	Saw	8	87.0	88
Do	...do	Iredell	...do	6	97.0	109
Do	...do	...do	Leather	1	15.0	10
Do	...do	...do	Cotton gin	3	56.0	31
Do	...do	...do	Flour and grist	30	456.0	480
Do	...do	...do	Cotton-factory	2	37.0	140
Do	...do	Alexander	...do	4	60.0	92
Do	...do	...do	Saw	1	12.0	15
Do	...do	...do	Furniture	1	7.0	10
Do	...do	...do	Blacksmithing	1	7.0	4

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[1] Compiled principally from returns of the tenth census.

TABLE OF POWER UTILIZED ON THE YADKIN RIVER.—*Continued.*

Name of stream.	Tributary to what.	County.	Kind of mill.	Number of mills.	Total fall utilized.	Total horsepower utilized.
Other tributaries of	Yadkin	Richmond	Flour and grist	3	50.0	54
Do	....do	....do	Cotton-gin	1	10.0	20
Do	....do	Montgomery	Flour and grist	9	.....	92
Do	....do	....do	Saw	1	8.0	15
Do	....do	Randolph	....do	6	52.0	66
Do	....do	....do	Flour and grist	13	206.0	192
Do	....do	Davidson	....do	28	240.0	446
Do	....do	....do	Saw	12	80.0	154
Do	....do	....do	Cotton-gin	1	9.0	4
Do	....do	Forsyth	Flour and grist	13	227.0	188
Do	....do	Stokes	....do	5	70.0	58
Do	....do	....do	Saw	3	.....	73
Do	....do	Anson	....do	2	23.0	36
Do	....do	....do	Flour and grist	7	125.0	137
Do	....do	Mecklenburg	....do	2	38.0	[illegible]
Do	....do	Rowan	....do	13	.....	132
Do	....do	Davie	....do	7	.....	75
Do	....do	....do	Saw	1	9.0	8
Do	....do	Yadkin	Flour and grist	12	....	171
Ararat river	....do	Surry	Cotton-mill Grist and flour	1	14.0	40
Do	....do	....do	Saw and grist	1	15.0	.....
Do	....do	....do	Grist-mill	1	16.0	.....
Stewarts creek	Ararat	....do	Cotton-mill	1	16.0	100
Lovills creek	....do	....do	Woolen-mill	1	8.0	30
Elkin creek	Yadkin	....do	Cotton-factory	1	22.0	70
Do	....do	....do	Shoe-factory	1	18.0	65
All other tributaries of	....do	....do	Saw	4	53.0	37
Do	....do	....do	Flour and grist	11	163.0	110
Do	....do	Wilkes	....do	12	140.0	102
Do	....do	....do	Saw	2	12.0	14

CHAPTER IX.

THE CATAWBA RIVER AND TRIBUTARIES.[1]

THE CATAWBA RIVER.

The Catawba river rises on the eastern slope of the Blue Ridge, in McDowell county, North Carolina, its main source being between the Blue Ridge and a spur of the same known as Bald mountain. It first flows nearly northeast into Burke county, and then nearly east between Caldwell and Alexander on its left and Burke and Catawba counties on its right. It then bends quite abruptly toward the south, and flows in a direction a little east of south between Iredell and Mecklenburg counties, North Carolina, and Lancaster, Kershaw and Sumter counties, South Carolina, on its left, and Catawba, Lincoln and Gaston counties, North Carolina, and York, Chester, Fairfield and Richland counties, South Carolina, on its right, uniting with the Congaree to form the Santee. It also flows for a short distance through Kershaw county, South Carolina. Its general course is seen to be nearly parallel to that of the Yadkin and Great Pee Dee. The river is known as the Catawba down as far as the mouth of the Big Wateree creek, in Fairfield county, South Carolina, below which point it is known as the Wateree. Its total length, in a straight line, is about 160 or 170 miles, but by the general course of the river it is nearly 225 miles, and over 300 miles if all its windings are followed. The length of the Wateree is about 105 miles, and the total length in South Carolina about 160 miles. The principal town on the river is Camden, South Carolina, there being no important ones above.

The stream is navigable as high as Camden, it being probably practicable to secure a depth of 2 feet and over up to this place. Above Camden the fall of the stream is so great that navigation is not practicable. About the year 1826 the state of South Carolina attempted to render the river navigable by means of locks, dams, and canals, and several very extensive and important works were constructed at great expense; but the undertaking is said to have been given up before the works were completed.

The total area drained by the stream embraces about 5225 square miles (of which 3085 are in North Carolina), and the drainage basin resembles in many respects that of the Yadkin, so that it need not be described here in detail. Like the Yadkin, the upper part of the river flows between parallel ranges of mountains, from which it receives a number of tributaries, affording considerable waterpower, and with a rapid fall, the width of the valley being about the same as that of the Yadkin. In the lower half of its course in North Carolina the valley of the Catawba is very narrow—not over 15 or 20 miles in width—and it receives only one important tributary, the South fork, which enters from the west near the South Carolina line, after draining an area of about 730 square miles. Below this point the valley is wider, but there are no tributaries of much importance. A few miles above Camden the river crosses the fall line, and below that point it partakes of the general character of the streams of the eastern division. The country drained by the river is very fertile and well populated, the productions being about the same as in the Yadkin valley. The valley abounds in building stone of the best kind. In Gaston, Lincoln, and Catawba counties there are fine deposits of iron ore and a number of deposits of gold ore; and in Gaston county are several valuable deposits of pyrites.

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[1] By Geo. F. Swain and J. A. Holmes.

[2] Annual Report Chief of Engineers, 1880, p. 915.

As regards bed, banks, freshets and bottoms, the river resembles the Yadkin, except that the bottoms are narrower in the lower half of its course in North Carolina. There are no lakes in the basin, but in the upper part the facilities for storage are said to be good. The soil in this upper part is generally porous, and at least 65 per cent. of the area in Burke, Alexander, Caldwell and McDowell counties is forest-covered.

The average rainfall in the basin is about 50 inches, of which about 12 fall in spring, 14 in summer, 10 in autumn, and 14 in winter. Toward the upper part of the stream, however, the rainfall in winter increases, and is probably greater than in the summer.

The elevation of the stream at different points is given in the following table, from which it will be seen that the fall is very great for such a large stream; and it is this large fall which has prevented the river from having ever been made navigable, although, as already remarked, many years ago the state of South Carolina expended a great amount of money endeavoring to make it navigable by means of locks, dams and canals.

The flow of the river was measured by Professor Kerr near Hickory, giving 2156 cubic feet per second, which is evidently not the low-season flow, as the drainage area above this point is not much over 1000 square miles.

Measurements of flow were made by the Geological Survey in 1896, 1897 and 1898 at Rock Hill, S. C. (drainage area given as 2987 square

TABLE OF DECLIVITY OF THE CATAWBA AND WATEREE RIVERS.

Place.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall between points.
	Miles.	Feet.	Miles.	Feet.	Feet per mile.
Junction with Congaree	0	80±			
			125	285	2.28
Crossing of Charleston and Northwestern railroad (narrow gauge)	125	365			
			25	131	5.24
Crossing of Charlotte, Columbia and Augusta railroad	150	496			
			20	52	2.60
Crossing of Piedmont Air Line (Southern) railroad	170	548			
			55	206	3.75
Crossing of Western North Carolina railroad	225	754			
			25	161	6.45
Five miles northwest of Hickory	250	915			
			18	104	5.78
Morganton	268	1,019			
Mill creek, two miles east of Old Fort		1,370	50	413	8.26
Mill creek at Old Fort	318	1,432			
			8+	598	74.75
Mill creek, last crossing of Western North Carolina railroad	326±	2,030			
			8+	628	78.50
Swannanoa gap (headwaters)	334±	2,658			

miles), and at Catawba, N. C. (drainage area given as 1535 square miles); and a statement of the results will be found on pp. 312-319 of this report.

At Rock Hill, S. C., the smallest flow measured was 1336 cubic feet per second, or 0.45 cubic foot per second per square mile, and the maximum was 46,040 cubic feet per second, or 15.5 cubic feet per second per square mile.

At Catawba, N. C., the smallest flow measured was 732 cubic feet per second, or 0.48 cubic foot per second per square mile, and the maximum was 9711 cubic feet per second, or 6.3 cubic feet per second per square mile.

These measurements, however, have not been extended over a sufficiently long period of time for them to serve as a reliable basis for computing the minimum or the low-season flow.

The map shows the railroads which cross the stream, from which it will be seen that it is easily accessible in almost all of its parts.

It may be mentioned here that the width of the river between the mouth of Wateree creek in South Carolina (where the Catawba becomes the Wateree) to the North Carolina line varies from 300 to 3000 feet, while its banks vary in height from 10 to 100 feet, being generally nearer the lower figure.

WATERPOWER ON THE CATAWBA RIVER.

We may now proceed to describe with as much detail as the information in hand will permit, the more important waterpowers on the Catawba in North Carolina, ascending from the mouth of the South fork at the South Carolina line.

The river was surveyed in 1824, under authority of the state of North Carolina, between the state line and Moores shoals, 10 miles below Morganton, by Mr. Hamilton Fulton, a portion of whose map and profile is in the office of the state geologist in Raleigh, from which the table of shoals further on is condensed.[1] Beside the shoals mentioned in the table, there are numerous others of smaller fall, but which, however, may be more favorable for power than those named, being perhaps more favorably located, and permitting the erection of high dams. All these points can only be determined by a survey.

Near the state line there are several shoals with falls of from 3 to 5 feet, some of which have been used to a limited extent, but there is so often trouble from high water that these sites are unsuitable for factories.

At Ross FALLS, located a short distance above the state line, there is said to be a fall of 8.1 feet in a distance of 0.9 mile.

At ROCK ISLAND SHOAL is now located, on the Mecklenburg side of the river, a grist- and saw-mill, owned by Hilton & Erwin. There is a wing-dam about 350 feet long and 5 feet high which gives a fall at the mill of about 9 feet, and the power used is about 60 horsepower. There were formerly located here the Rock Island woolen-mills.

The TUCKASEGEE SHOAL, about 9 miles above the state line and one mile below the Carolina Central railroad crossing, is a waterpower of considerable importance, and has been more largely developed than those below it. The natural fall here is said to be 11.22 feet in a distance of 1.02 miles. The Tuckasegee Manufacturing Company's cotton-mill, located on the Gaston or west side of the shoal, contains 55 cards and 6000 spindles, all operated by water, about 150 horsepower being used. There is a wooden wing-dam about 200 feet long, giving a fall of water at the mill of 11 feet. There is never any trouble from low water, but high water interferes with the running of the mill during an average of 6 days in the year. As seen from the table given on page 212, the "minimum" or lowest possible power of the dryest season here should be about 425 horsepower.

MOUNTAIN ISLAND SHOAL.—Three miles above the Tuckasegee shoal is the fourth power on the Catawba in North Carolina, at Mountain

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[1] Extract from Annual Report Chief of Engineers, 1876, p. 33, *et seq.*

Island shoal, about 3 miles above the Carolina Central railroad, and above the mouth of Dutchmans creek. The fall in the river between a point one mile above the factory, or a little above the head of the shoal, and the railroad bridge below is 38 feet,[1] but of this fall nearly 30 feet occurs in one mile near the factory. The bed of the stream is rock, the banks on the east side steep, while they are shelving on the west and very favorable for building, with no danger from high water. The power is utilized to a small extent by the cotton-factory of the Catawba Electric Power Company, containing 6300 spindles, 100 looms and 48 cards. At the head of the shoal is a series of three small islands near the right bank, with the distance of only a few feet between them and the shore, and between the islands and the shore a certain amount of water flows naturally, with no dam to turn it in. This water is all that is used by the factory, there being no dam at the head of the islands except a wing-dam of wood, 300 feet long and 4 feet high, used to turn the water into the "race," and the only other dams are three slough-dams, connecting the islands with each other and the lowest one with the shore, the two former of which are of rough stone and the third of crib-work, and about 40 feet long and 8 feet high. From the foot of the lowest island an artificial race about 600 feet long leads to the factory, where a fall of 22½ feet is used and about 190 horsepower; in addition to which there is a grist- and saw-mill and a cotton-gin, using together 50 to 60 horsepower and 15 to 16 feet fall. Full capacity can be secured all the time. The total distance between the head of the small islands referred to and the factory is about three-quarters of a mile, below which the fall continues for a short distance. The fall in the canal is considerable, and the total fall down to the factory is in the neighborhood of 26 feet.

The drainage area above this shoal being about 1538 square miles, the power is estimated as follows:

TABLE OF POWER AT MOUNTAIN ISLAND SHOAL.

State of flow.	Drainage area.	Fall.	Flow, per second.	Horsepower available, gross.		
(See pages 54 to 59.)[2]	Square miles.	Feet.	Cubic feet.	1 foot fall.	25 feet fall.	30 feet fall.
Minimum	1,538	30[3]	300	34.1	850	1,000
Minimum average for the low season			380	43.2	1,080	1,300
Average for the low season of average dry years			450	51.1	1,275	1.500

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[1] From information furnished by B. S. Guion, C. E., Lincolnton, N. C.

[2] For later measurements of the flow of Catawba river, see pp. 312 to 319.

[3] See description.

The whole of this power is easily available on the west bank, with good facilities for buildings and canals. A series of mills could be built, using an average fall of 25 feet or more, and with little trouble from high water, and none from ice. The east side is not so favorable. It is to be remarked that the pond would probably be small, and the power could not be concentrated into fewer than 24 hours except by reservoirs elsewhere. The shoal is 12 miles from Charlotte and 3 miles from the Carolina Central railroad, with which it might easily be put in communication by rail. It is in the cotton-belt, and in a most healthy part of the country. It is one of the most available powers in North Carolina.

Just above Mountain island the river makes a remarkable bend, or horseshoe, the distance by land across the chord being 1½ miles, while it is 7½ miles around by the river.[1] This bend has been talked of as a site for waterpower, which would afford a large fall if the bend were cut through. According to Professor Kerr, however, the river is sluggish along the bend, and the total fall is small, some 9 or 10 feet only.

Of the shoals above Mountain island but few have been utilized, and these to only a small extent. They have not been examined by the writers, and the information here given concerning them has been derived from the reports of the Chief of Engineers of the United States Army, the chart made by Hamilton Fulton in 1824, and by correspondence from persons living in the region through which the river passes. The names given to these shoals are those which were in use many years ago, and in a few cases other names may have been in part substituted for those here given.

COWAN FORD SHOAL, the first important shoal reported above Mountain island, has a fall of 27.25 feet in a distance of 4.17 miles. As shown in the table below (p. 212), the estimated minimum power here for the dryest seasons is 900 horsepower; but the extent to which this power can be rendered available can only be determined by a careful survey of the entire shoal.

BEATTIES FORD SHOAL is about 6 miles further up the river. This latter is reported to be a good power but is undeveloped. Its availability can be determined only by a careful examination. It has a fall of 13 feet in 2.38 miles, and 8 feet of this fall is said to occur in about 1000 feet, where the stream has a width of about 100 yards and a good rock bottom suitable as a foundation for a dam. Its estimated power for the total fall (13 feet) in the dryest of dry seasons is 420 horsepower.

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[1] Annual Report Chief of Engineers, 1876, app. G, p. 31.

In ordinary seasons the power would be considerably greater. A fuller tabular statement of the power of this shoal is given below (p. 212).

The **Monbo shoal** (old Granite shoal), 2 miles above Sherrills ford and 2 miles below the Buffalo shoal, is the first of the shoals above Mountain island which is now utilized to any considerable extent. Here the cotton-mill of the Monbo Manufacturing Company (formerly the Granite shoals mill of the Catawba Manufacturing Company), operating 7 cards, 43 looms and 1600 spindles, is located on the west bank of the river 8 miles southeast of Catawba, the nearest station on the Western North Carolina railroad. At this point the river is about one-fourth mile wide and divided by islands. From the Monbo mill a dam 225 feet long and 4 feet high extends across a division of the river to Goat island, and thence a wing-dam 2 feet high extends up the river nearly 800 feet to the lower end of Long island, which many years ago was known as Crawfords island. This wing-dam and island divide the river into two parts; the western portion forms the power for the Monbo mill, the eastern or Iredell side is still an undeveloped shoal. The Monbo mill has a six-foot fall of water at the wheel and uses about 60 horsepower, this being but a small part of the power available. The running of the mill is never interfered with by low water, but high water interferes during a few days of each year.

Long Island shoal (formerly known as the Crawford Island shoal), about one mile above the Monbo mill, like the latter, is located on the Catawba or west bank of the river, and derives its power from a shoal in that part of the river between the west bank and Long island. The cotton factory (Long Island mill) located here is 7 miles southeast of the nearest railroad depot—Catawba station, on the Western North Carolina railroad. It operates 10 sets of cards and 3000 spindles, using about 60 horsepower, a small part of the power available. The dam is about 300 feet long, extending from the west bank to Long island, and is 3 to 6 feet high, the fall of water at the mill being 6.5 feet. The old Crawford Island shoal as measured by Hamilton Fulton (1824) is recorded as having a fall of 23.44 feet in 1.69 miles, and this shoal has an estimated minimum of 700 horsepower in the dryest of dry seasons, while in ordinary seasons the power would be much greater. Whether this measurement included both the Monbo and Long Island shoals as described above, or only the latter, cannot now be determined without a remeasurement. The table below gives the estimated power of the total fall (23.44 feet) at these shoals (p. 212).

Buffalo shoal, about 2 miles above Long Island shoal, has a fall of 11.4 feet in a little more than half a mile (.66). It is said to be a good site for waterpower, but is undeveloped at the present time. The minimum dry season power estimated for this fall (11.4 feet) is 325 horsepower, while in ordinary seasons the power would be much greater. This shoal is but a short distance below the Western North Carolina railroad. (See table of power, p. 212.)

About 7 miles above Buffalo shoals and a less distance above the railroad, is a shoal with a fall of 9.7 feet in a distance of 2.18 miles, and 2 miles higher up the river is another shoal with a fall of 8.6 feet in a distance of 1.32 miles. The first of these has an estimated minimum dry season flow equivalent to 250 horsepower; and the latter of 225 horsepower. During ordinary seasons the power would be much greater than this (p. 212).

Lookout shoal, the lower end of which is 1.3 miles above the last-mentioned shoal and 6 miles (across country) above the Western North Carolina railroad at Catawba station, has the greatest fall of any shoal on the river in North Carolina, the descent being 54.25 feet in a distance of 3.2 miles. About 30 feet of this fall is said to occur in a distance of three-fourths of a mile, the river at this place having a width of about 900 feet. The bed of the river is of rock, and there is said to be an abundance of stone of good quality convenient for building, and good factory sites on both sides of the river. The shoal has been developed to only a small extent, being used for a saw- and roller flour-mill. It is evidently an excellent waterpower, as shown by the table below, which indicates the minimum estimated power for the total fall (54.25 feet) in the very dryest possible season to be 1450 horsepower, while the power during ordinary dry seasons would be much greater than this (p. 212).

Lower Little river shoal, about one and one-third miles above the top of Lookout shoal, is between the upper end of Druin island and the lower end of Three-cornered island, with a fall of 9.7 feet in a length of 1.16 miles. Its estimated minimum in the dryest season is 260 horsepower, that in ordinary dry seasons being much greater than this. Between the upper end of this shoal and the mouth of Lower Little river are small shoals having a fall of 3.36 feet in a distance of nearly one mile.

Canoe-landing shoal, about two miles above the mouth of Lower Little river, has a fall of 8.94 feet in a distance of 1.87 miles. As will be seen from the tables given below, the estimated minimum power of this shoal on the basis of the natural fall (8.94 feet) in the dryest season of the dryest year is 225 horsepower. During ordinary dry seasons the power would be much greater (page 212).

Great Falls shoal, just above the Canoe-landing shoal, has a fall of 14.82 feet in a distance of 1.02 miles. It has an estimated minimum in the dryest possible season of 375 horsepower, while in ordinary dry seasons the power would be much greater than this (page 212).

These two shoals considered together have a total fall of 23.76 feet in a distance of 2.89 miles. And it may be possible to develop the two together into one fine power, but the cost and practicability of this can be determined only by careful surveys.

Horseford shoal, 3 miles north of Hickory, and about 5 miles below the crossing of the Carolina and Northwestern (narrow gauge) railroad, as will be seen from the table below, has a fall of 31.4 feet in 2.9 miles. The power is being utilized here to a limited extent only. On the upper part of the shoal a fall of 6 feet is being used to run the Catawba lumber-mills, and on the middle portion of the shoal are located the Horseford saw- and grist-mills (the latter with three run of stones), using about 25 to 30 horsepower. This is undoubtedly one of the largeest and most available, as well as most accessible, waterpowers of the upper Catawba river. It has been purchased recently by the Odell Manufacturing Company, with the reported purpose of developing the entire power at an early date. Transportation facilities are good, the site being within 3 miles of the Western North Carolina railroad at Hickory, and within a shorter distance of the narrow gauge railroad. A track could easily be built to the shoals from either of these roads. The table below indicates the estimated minimum power at this shoal in the dryest of dry seasons to be 700 horsepower, and for ordinary dry seasons the figure would be considerably larger (page 212). The development of this shoal is said to be already in progress.

Devil shoal, the lower end of which is 6 miles above the Horseford shoal, has a fall of 13.78 feet in a distance of 1.01 miles and is said to be a fine location. The estimated power of this shoal is indicated in the general table given below, where it will be seen that the estimated minimum in the dryest season of the dryest year is 290 horsepower, and much greater during ordinary dry seasons (p. 212). The shoal is about three miles from the Western North Carolina railroad, very close to the line of the narrow gauge railroad, and is about 6 miles northwest of Hickory. A ledge of rock is reported to extend entirely across the river, offering a good site for a dam.

Rocky ford shoal, at Morganton, and some 20 miles above Devil shoal, has a natural fall of 9.5 feet in a distance of about 1500 feet. As shown in the table below, the estimated minimum in the dryest possible season is 100 horsepower, while during ordinary dry seasons the power would be considerably greater than this (see table on p. 212). This power was formerly used for a grist-mill and there was a dam 2 feet high and 400 feet long, giving a fall of 11.5 feet at the mill; and the wheel gave 60 to 70 horsepower with water wasting all the while. This mill is not now in use.

Above Morganton the river has a rapid fall, but it is more uniform than below, the shoals being more numerous, but not with such sudden descents. Between Morganton and the mouth of Mill creek there are 197 shoals, with an average fall of about 2 feet, the distance being 50 miles. The valley narrows gradually to one-half mile in width.

In McDowell county the river forks into Mill creek, which the Western North Carolina railroad follows, and the South Catawba, on which occur the Catawba falls, where the fall is said to be several hundred feet in a short distance, but the stream is too small to be much used for power. Both of these streams, as well as the others which enter the Catawba in McDowell county, are mountain streams, with a large fall and often abrupt descents of many feet, forming cascades and cataracts of great beauty. Some of them are used by small grist- and saw-mills.

SUMMARY OF POWER ON THE CATAWBA RIVER.[1]

Locality.	Distance from state line (or mouth of South fork).	Drainage area.	Rainfall.					Total fall.		Horsepower[2] available, gross.			Utilized.	
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length of shoal.	Minimum.	Minimum average for the low season.	Average for the low season of average dry years.	Horsepower, net.	Fall.
	M's	Sq.m.	In.	In.	In.	In.	In.	Feet.	Miles					Feet.
Mouth of South fork Catawba (state line)	.0	......	....	....	....	....	....	......	......				......	......
Ross falls	1.2	1,725	12	14	10	14	50	8.13	0.90	300	400	450	......	......
Rock Island shoal	....	1,700	12	14	10	14	50	9.00	....	260	400	480	60	9.0
Tuckaseegee shoal	9	1,670	12	14	10	14	50	11.22	1.02	425	525	600	150	11.0
Mountain Island shoal	15	1,538	12	14	10	14	50	46.52	3.10	1,600	2,000	2,300	250	22.0
Abernathy's falls	18	1,500±	12	14	10	14	50	3.93	0.22	130	170	200	......	......
Cowans ford shoal	28	1,455	12	14	10	14	50	27.25	4.17	900	1,125	1,300	......	......
Beatties ford shoal	34	1,420	12	14	10	14	50	18.00	2.38	420	520	600	......	......
Sherrills ford shoal (Monbo shoal)	50	1,342	12	14	10	14	50	13.13	1.88	400	500	600	60	6.0
Crawford Island or Long Island shoal	52	1,307	12	14	10	14	50	23.44	1.69	700	870	1,000	60	6.5
Small shoals	54	1,290	12	14	10	14	50	3.93	0.65	120	150	175	......	......
Buffalo shoals	55	1,287	12	14	10	14	50	11.41	0.66	325	400	475	......	......
	63	1,205	12	14	10	14	50	9.71	2.18	250	325	375	......	......
	64	1,200	12	14	10	14	50	8.64	1.32	225	300	350	......	......
Lookout shoals	65	1,184	12	14	10	14	50	54.25	3.20	1,450	1,850	2,100	small	small
Lower Little river shoals	71	1,180	12	14	10	14	50	9.70	1.16	260	325	375	......	......
Canoe-landing shoal	73	1,125	12	14	10	14	50	8.94	1.87	225	280	325	......	......
Great falls	75	1,100±	12	14	10	14	50	14.82	1.02	375	475	515	......	......
Horseford shoal	85	964	12	14	10	14	50	31.43	2.91	700	875	1,000	small	small
Shoal	89	935	12	14	10	14	50	8.88	1.82	190	240	275	......	......
Devil shoal	91	918	12	14	10	14	50	18.78	1.01	290	360	425	......	......
Rocky ford shoal	102	557	12	14	10	14	50	9.50	0.30	100	140	160	......	9.5

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[1] For measurements of the flow of the Catawba river, see pp. 312 to 319.

[2] See pages 54 to 59.

TRIBUTARIES OF THE CATAWBA—SOUTH FORK.

The first of the tributaries to the Catawba river in North Carolina is the South fork, which enters the main stream just at the state line, and which is noted for its waterpower. It is formed near the center of Catawba county by the union of two forks, Henrys and Jacobs forks, both of which take their rise among the South mountains in the southern part of Burke county and flow nearly east into Catawba county. From the junction of these forks the river pursues a course a little east of south through Catawba, Lincoln and Gaston counties, entering the Catawba river at the southeastern corner of the latter, after draining a total area of about 730 square miles. Its tributaries, with the exception of the forks above mentioned, are all small streams, not worthy of special notice. The river passes within a mile or two of Lincolnton and within 3 or 4 miles of Newton, the county-seats of Lincoln and Catawba counties, respectively, and the most important towns in the vicinity. The character of the drainage area and of the stream, differing in no particular respect from that of the Catawba river in its course in North Carolina, need not be described in detail. The rainfall is about 51 or 52 inches, distributed as follows: spring, 12; summer, 14; autumn, 10; winter, 16.

The stream has a rapid fall from Lincolnton down to its mouth, as will be seen from the following table, and in fact it is nothing but a series of rapids between those points, with few bottoms subject to overflow. From Lincolnton up to the junction of Henrys and Jacobs forks it is flat, with no large powers, and with considerable areas subject to overflow.

TABLE OF DECLIVITY OF THE SOUTH FORK OF THE CATAWBA.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Difference of level between points.	Fall between points.
	Miles.	Feet.	Miles.	Feet.	Feet per mile.
Crossing of Charlotte and Atlanta Air Line railroad	8	610	17	94	5.5
Crossing of Charleston and Northwestern (narrow gauge) railroad	25	704	6	45	7.5
Crossing of Carolina Central railroad	31	749			

There are no reliable records of gaugings of the river. The stream is subject to heavy freshets, which overflow the banks in places, but the fall is so rapid below Lincolnton that the rise is not extreme in that portion of its course. The bed is uniformly rock at the shoals, overlaid between by gravel, clay and sand. The stream is easily accessible from three railroads, as the map shows. The Charleston and Northwestern (Chester and Lenoir) narrow gauge road has done much towards opening up the resources of the region along this stream, as well as on the Catawba.

The more important powers on this stream are as follows, in their order, ascending:

STOWESVILLE COTTON-MILL, 3 miles from Belmont station on the Southern railroad, is utilizing the first important shoal on the river, being located on its east bank, about 4 miles above its junction with the Catawba. The mill contains 24 looms, 2250 spindles and 16 cards, operated by waterpower alone. The dam is 5 feet high and 200 feet long, built of wood and stone, making a small pond, giving, through a race 500 to 600 feet long, a fall of 16 feet at the wheel. There is ample power all the time, but high water causes occasional short interruptions, the power used being perhaps 50 to 60 or more horsepower for the factory. Near the latter is a grist-mill, and on the opposite side of the river a saw-mill and cotton-gin, the total power used being perhaps 100 horsepower. The factory is run night and day, and there is always waste of water. The estimate of the power available at this place will be found in the table.

SPRING SHOAL, the next power on the river, is the site of the McAden mills, located six miles above the Stowesville mill, just above the mouth of Duharts creek and 1½ miles from Lowell station on the Southern railroad. The mill contains 320 looms and 15,000 spindles. The dam is 5 feet high and 500 feet long, and the fall at the factory is 23½ feet, developing one of the best powers on the river. The fall of the shoal is about 24 feet in about 500 feet, and in less than half a mile there is said to be nearly 30 feet fall over a bed of solid rock, with rock banks, very favorable for building on one side. The dam, built in 1881 at a cost of $1200, is of timber bolted to the rock, extending diagonally across the stream, 2½ feet high and 600 feet long, backing the water about three-fourths of a mile. From it a race 350 feet long, 50 feet wide and 6 feet deep leads to the factory, where the fall is 23½ feet. The two 42-inch Victor turbines on horizontal shafts are said to be capable of developing 750 horsepower under a head of 24 feet. Only part of this is necessary to operate the machinery. The table on page 218 gives an estimate of the power available. This shoal is in the middle of the cotton belt, with good building stone (gneiss) near-by, an abundance of timber, and in very healthy country (Plate IX).

MASSEY SHOAL.—This name has been applied primarily to the lower of three shoals so close together that they can be developed as one power. The upper shoal was formerly occupied by the mill of the

B -McADEN MILLS AND TAIL RACE, SOUTH FORK OF CATAWBA RIVER

A DAM AND HEAD OF RACE, McADEN MILLS

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Woodlawn Manufacturing Company, and the middle shoal by the cotton-factory of the Lawrence Manufacturing Company; but all three of the shoals now belong to the Coats Company of Philadelphia. They have a combined fall of 25.9 feet in a distance of about a mile. The estimated minimum power of the combined shoals in the dryest of dry seasons is about 375 horsepower, while during ordinary dry seasons it would be much greater than this.

SPENCER MOUNTAIN MILL, 3 miles above the Massey shoal and 12 or 13 miles above the mouth of the river, contains 6000 spindles and 30 cards, and uses about 100 horsepower. The wooden frame dam, 600 feet long and from 2 to 7 feet high, gives a fall of 13 feet at the wheel through a race 190 feet long. The fall here might be increased, it is said, the available fall being reported as 18 feet or more. There is considerable fall below the mill, which is therefore never troubled with high water. If the full 18 feet fall be developed the resulting power should not be less than 240 horsepower even in the dryest possible seasons, and during ordinary seasons it should be much greater (p. 218).

The next is an unimproved site with about 4 feet fall, where there was formerly a mill.

FRIDAY SHOAL, a rock shoal, said to have 10 feet fall and to be a good power. It is below the mouth of Kettle-shoal creek and about one mile from the Carolina and Northwestern railroad. This site is now occupied by the cotton-mill of the Harden Manufacturing Company, which contains 2080 spindles. The dam is 6 feet high and 200 feet long, giving a fall of 16 feet at the mill, which probably uses 80 to 85 horsepower, available during the dryest possible seasons.

HIGH SHOALS, the next power, is one of the best on the stream. It is situated between the mouths of Kettle-shoal creek and Hynes creek, 7 miles from Lincolnton and one from the Carolina and Northwestern railroad, which crosses the river just below it. The stream here flows over a ledge of solid gneiss rock, the fall being about 22 feet in 300; but the fall continues below for some distance, amounting to 27 feet in 600, and probably 35 feet in a quarter of a mile or more. The banks are quite abrupt on both sides, but there is still abundance of room for building, the best location being on the left bank. The whole flow of the stream can easily be controlled, the facilities being in all respects most excellent. The width of the stream is 300 feet above the fall, and probably greater below, the channel being cut up with islands and rocks. Just below the principal fall a small creek enters the river from the left, which could be utilized well as a tail-race if the mills were situated on the hill by which it flows. This power was used until about 25 or 30 years ago to drive iron works (rolling-mill, nail-factory and others), together with a grist- and a saw-mill situated on the left bank, and using together 180 horsepower. The ruins of the old iron works are still to be seen, and it is evident that they utilized a fall of between 22 and 27 feet. The drainage area above is 518 square miles. No gaugings have been made which will enable us to estimate the power at this fine site. In the immediate vicinity are some of the most noted deposits of iron ore in the state. The Carolina and Northwestern railroad will afford the best facilities for transportation. It is expected that this excellent power will be fully developed in the near future by a company of which D. A. Tompkins of Charlotte is the manager.

LONG SHOALS COTTON-MILL is situated on the river just below the mouth of Indian creek, and four miles below Lincolnton, on a shoal of the same name. The banks here are favorable for building on the left side, where the mill is situated. This mill contains 5200 spindles, and is run by waterpower alone. The fall of water at the mill is 13 feet from a race about 300 feet long, and it is expected to develop 300 horsepower in ordinary seasons. The dam, of wood and stone, is 13 feet high and 300 feet long.

MOSTELLERS SHOAL, unimproved, about one-half mile above Long shoal, has a fall of 7 feet over rock bottom.

The LINCOLN MILL, the next power on the river, is on the site of the old paper mill owned by W. & R. Tiddy, of Charlotte, and is located four miles below Lincolnton. The mill contains 5000 spindles. The dam is of wood, about 276 feet long and 11 feet high, giving a fall of 13 feet at the wheel, and it is said that 150 horsepower can be obtained here at all times and with no waste in summer.

THE LABORATORY COTTON-MILL, containing 6500 spindles, is located on the river half a mile above the Lincoln mill and above the mouth of Indian creek but below that of Sand branch. The dam is of logs, 6 feet high and 500 feet long, giving a fall of 9 feet at the mill. The pond is large, and the power used can be obtained practically all the time, though there is a reported loss of a few days on account of high water.

The LINCOLNTON SHOAL, located within the town limits, is the next power and is the site of Elm Grove cotton-mill, which was formerly operated by waterpower, obtained from a fall of 6½ feet. But the factory is now operated entirely by steam; the waterpower has been abandoned and the dam removed. Further up the river and on its higher tributary branches there are a number of excellent small powers, some of which are utilized in operating saw- and grist-mills and others are undeveloped, but no special examination of these has yet been made, and they cannot be described in the present report.

It will be seen that the south fork of the Catawba is an excellent stream for power, a large amount of which is already utilized. The climate in the vicinity is salubrious, the agricultural and mineral resources of the country very large, and the facilities for manufacturing in all respects hardly to be excelled.

TRIBUTARIES OF CATAWBA ABOVE SOUTH FORK.

DUTCHMANS CREEK.

Dutchmans creek enters the Catawba just above the crossing of the Carolina Central railroad, and is the next tributary worth mentioning above the South fork. It rises in Lincoln county and flows nearly south, draining an area of 88 square miles, and is a small stream with only three powers worth referring to.

The **MOUNT HOLLY MILL**, located in the town of Mount Holly, one and one-half miles above the mouth of the creek, operates 2500 spindles. Here a fall of 8 feet is used and 50 horsepower is obtained for nine months of the year and 35 for the remaining three, a steam-engine being used for that time. There is no water waste in dry summers, the mill being run all the time. There is some trouble from high water, the stream being subject to heavy freshets, and there not being many low grounds subject to overflow.

The **NIMS MANUFACTURING COMPANY'S COTTON-MILL**, also on Dutchmans creek, contains 3000 spindles, operated by waterpower, supplemented by steam-power for two or three months of the year. The dam is 8 feet high and 110 feet long, the fall of water 10 feet, and the power said to be developed 80 to 100 horsepower for nine months.

The **MARIPOSA COTTON-MILL**, containing 1664 spindles, is located on Leipers creek, known as Dutchmans creek in the lower part of its course, about 12 miles above its junction with the Catawba river.

The dam is of wood, 10 feet high and 100 feet long, and backs the water about one-fourth of a mile with an average width of 60 feet. There is no race, the fall at the wheel is 14 feet, and about 60 horsepower is developed by a 40-inch Leffel turbine. It is stated that about 100 horsepower is required to operate the machinery, and the deficiency, amounting to about one-half the required power, is supplied by an auxiliary steam-plant of 75 horsepower capacity.

Above this factory there are only small saw- and grist-mills, the latter generally with two pair of stones. There are some sites not occupied where there have formerly been mills. The dams are all of wood, founded on rock and sometimes bolted down. The stream averages 100 feet in width for some distance from its mouth. On one of the tributaries a small amount of power was formerly used for an iron-furnace.

SUMMARY OF POWER (ESTIMATED) ON THE SOUTH FORK OF THE CATAWBA.

[Powers are for natural flow, without drawing down water at night in pond.]

Locality.	Distance from mouth.	Drainage area.	Rainfall.					Total fall.		Horsepower available, gross.[1]			Utilized.		Remarks.
			Spring.	Summer.	Autumn.	Winter.	Year.	Height.	Length of shoal.	Minimum.	Minimum low season.	Low season, dry years.	Horse-power, net.	Fall.	
	Miles	Sq.m.	In.	In.	In.	In.	In.	Feet.	Feet.					Feet.	
Stowesville cotton-factory, etc.	6±	720	12	14	10	16	52	16.0	....	240	320	373	100±	16.0	
Spring shoal	8±	688	12	14	10	16	52	24.0	500±	350	450	500	450	23.5	Solid rock.
Coats Co. shoals	9-10	675	12	14	10	16	52	25.9	5,000±	375	480	550	0	0.0	
Spencer Mountain mill	13±	640	12	14	10	16	52	18.0+	....	240	320	375	100±	13.0	
Unimproved site	......	600±	12	14	10	16	52	4.0	....	50	70	75	0	0.0	
Friday shoal........................	20±	550	12	14	10	16	52	16.0	....	160	240	280	80	16.0	
High shoal.........................	22±	518	12	14	10	16	52	27.0	600	280	380	450	0	0.0	Rock.
Long shoals mill..................	......	493	12	14	10	16	52	13.0	....	118	165	177	100	13.0	
Mostellers shoal	......	450±	12	14	10	16	52	7.0	....	60	85	100	0	0.0	Rock.
Lincoln mill	......	430	12	14	10	16	52	13.0	....	104	149	169	100	13.0	No waste in summer.
Laboratory mill	......	400+	12	14	10	16	52	9.0	....	68	90	101	110	9.0	Mill run 12 hours. No waste in dry weather.
Lincolnton shoal	......	325	12	14	10	16	52	6.5	....	40	55	60	0	0.0	Mill run by steam.

[1] See pages 54 to 59.

CROWDERS CREEK.

The CROWDERS MOUNTAIN MILL is located on Crowders creek about four miles from Kings Mountain station on the Southern railroad. The mill contains 2500 spindles and 63 looms, operated by water and steam-power combined, about 75 horsepower being developed by the water-power plant. The race is a steel pipe 125 feet long and 2 feet in diameter, giving a fall of 50 feet at the mill and developing 75 horsepower by means of a 17½-inch Leffel turbine.

It is stated that about 100 horsepower is necessary to run the machinery, and there is an auxiliary steam-plant of 125 horsepower capacity.

THE MINOR TRIBUTARY STREAMS.

There are no important tributaries to the Catawba in Mecklenburg, Catawba and Iredell counties, the small streams which join the river being only capable of running small grist-mills with one or two run of stones, for which purpose they are in some cases used. The tributaries from the north are more important. The three Little rivers—Upper, Middle and Lower—have considerable fall, but are very small streams, draining respectively 31, 33 and 53 square miles.

On *Lower Little river* there are several grist-mills and one small cotton-factory three miles south of Taylorsville—the TAYLORSVILLE COTTON-MILL, with 700 spindles and 24 looms, operated by thirty horsepower, available all the year round. The dam is nine feet high and 200 feet long and the fall 13 feet. There is also a saw-mill operated by this power along with the cotton-mill. Both above and below this cotton-factory are a number of small powers on which are located grist- and saw-mills. On both Middle and Upper Little rivers are a number of grist- and saw-mills and undeveloped sites suitable for the same. These streams can probably hardly be depended on for one horsepower per foot-fall in dry seasons at their mouths.

The tributaries of the Catawba in Caldwell and Burke counties are larger and of more importance. *Gunpowder creek*, from the north, drains an area of about 31 square miles, and is about like the Little river in general character. Near Granite falls on this creek is located the GRANITE FALLS MANUFACTURING COMPANY'S COTTON-MILL, containing 3352 spindles and 4 sets of cards operated by waterpower only. The dam is 14 feet high, 120 long and the fall is 48 feet. *Lower creek*, from the same side, drains 117 square miles, but is said to have little power. *Johns river*, also from the north, drains 120 square miles, but is not used except for one or more saw-mills, although it has considerable fall. *Upper creek* (north side) drains 45 square miles, and has a cascade about 18 miles from Morganton, but of little value for power.

LINVILLE RIVER.

This river rises on the west slopes of the Grandfather mountain, in Mitchell county, and flows in a general southerly course near the west border of Burke county until near the southern end of Linville mountains, where it bends southeastward and joins the Catawba river. It has a drainage area of 90 square miles, nearly all of which is forest-covered and much of its upper part with gentle slopes and occasional swampy areas. The rainfall of the Linville area is given by the United States Weather Bureau as 46 inches for the year, distributed as follows: spring, 11.50; summer, 13.50; autumn, 9.50; winter, 11.50. The drainage area of the river and tributaries above the falls is 50 square miles, while that of the entire river above its mouth is 90 square miles. Plate X, shows the general appearance of Linville falls (fig. B) and of the rapids just above the falls (fig. A).

At the falls, which are located about 3 miles below the Mitchell-Burke county-line crossing and about 22 miles above the mouth of the river, there is one perpendicular plunge of 40 feet, and the cascades just above give an additional fall of 50 feet more in a horizontal distance of less than 100 feet, thus giving an available natural fall of 90 feet. The power at this place, owned by the Linville Improvement Company of Morganton, is entirely undeveloped.

There are also several lesser undeveloped powers on the stream within a few miles above the falls, owned by the Linville Improvement Company; one on the Linville river at the mouth of Grandmother creek, 1½ miles southwest of the town of Linville, Mitchell county, where there is a fall of 20 feet, and the other on the Grandmother creek near its mouth with a fall of 40 feet. The fall at both of these can be considerably increased by the construction of inexpensive dams. For a distance of 10 miles in a general southerly course below the falls the river runs as a series of cascades through a narrow gorge from 500 to nearly 2000 feet deep, the walls being cut down through the bedded Linville quartzites above and granite below. At a point about 8 miles above its mouth the river emerges from this gorge and runs with a less rapid but by no means sluggish current across the open but hilly border of the plateau to its junction with the Catawba. In the first six miles below the "falls" the descent averages 208 feet[1] to the mile; and from just above the "falls" to the lower end of the gorge, in a distance of 10 miles, there is a fall of about 1800 feet. Along the upper 6 or 7 miles of this distance the bottom of the gorge is scarcely wider than the stream, and the large boulders of quartzite and granite rock at the foot

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[1] As determined by a line of levels run by W. E. Walton, C. E., of Morganton.

A UPPER LINVILLE FALLS OR RAPIDS

B—LINVILLE FALL (LOWER FALL)

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of the bluffs and in the bed of the stream render travelling, even on foot, exceedingly difficult. And the location of factories of any kind in this part of the gorge would be entirely impracticable.

One way in which this power might be developed is that of conveying the water of the river from just above the "falls" down the gorge in iron pipes to the lower end of the gorge or to a point 2 miles above, where a power-house could be located and the power conveyed to Morganton (about 15 miles) or some still nearer point on the Southern railroad (about 7 miles). A large power can be developed in this way, but sufficient gaugings have not yet been made to serve as a basis for estimating accurately its amount.

On the lower part of the river are several good powers. The lowest is one mile above the mouth of the river, where Major J. W. Wilson has a saw- and grist-mill with a fall of 9 feet; the next, 3 miles above this (following the stream), is Dickson's grist-mill with a fall of 9 feet; and 4 miles above this latter is an undeveloped power with a natural fall of 8 feet.

For tabular statement of utilized power on the Catawba river and tributaries see page 222.

TABLE OF UTILIZED POWER ON THE CATAWBA RIVER AND TRIBUTARIES.

Name of stream.	Tributary to what.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horse-power used.
Catawba	Santee	Mecklenburg	Grist- and saw-	1	9.0	60
Do	....do	Gaston	Cotton-factory	1	11.0	150
Do	....do	....do	....do	1	22.0	180
Do	....do	....do	Grist- and saw-	1	16.0	60
Do	....do	....do	Cotton-gin			
Do	....do	Iredell	Flour- and grist-	1	15.0	15
Do	....do	....do	Saw	2	32.0	40
Do	....do	Catawba	Flour- and grist-	1	6.0	16
Do	....do	....do	Cotton-factory	1	6.0	60
Do	....do	....do	....do	......	6.5	60
Do	....do	....do	Saw- and flour-	1	....	....
Do	....do	Alexander	Flour- and grist-	1	3.0	6
Do	....do	Caldwell	....do	1	9.0	20
Do	....do	....do	Saw-mill	2	21.0	30
Do	....do	....do	Wagon-factory	1	9.0	10
Do	....do	Catawba	Saw mill	1	....	....
Do	....do	....do	Saw- and grist-	......	....	30
Do	....do	McDowell	Flour- and grist-	2	23.0	22
South fork Catawba	Catawba	Gaston	Cotton-factory	......	16.0	60
Do	....do	....do	....do	......	23.5	450
Do	....do	....do	....do	......	13.0	100
Do	....do	....do	....do	......	16.0	80
Do	....do	....do	....do	......	13.0	300
Do	....do	Lincoln	....do	......	13.0	....
Do	....do	....do	....do	......	9.0	....
Do	....do	Catawba	Flour- and grist-	3	52.0	37
Do	....do	....do	Saw	3	50.0	34
Tributaries to	South fork Catawba	Gaston	Flour- and grist-	8	128.0	122
Do	....do	....do	Saw	4	68.0	100
Do	....do	Lincoln	Flour- and grist-	8	131.5	113
Do	....do	....do	Saw	3	32.0	35
Do	....do	....do	Cotton-gin	5	48.0	44
Do	....do	....do	Leather works	3	52.0	28
Do	....do	....do	Millwrighting	1	18.0	15
Do	....do	Catawba	Flour- and grist-	4	60.0	47
Do	....do	....do	Woolen	1	8.0	8
Do	....do	....do	Iron casting, etc	1	10.0	20
Do	Catawba	Gaston	Cotton-factory	1	8.0	50
Do	....do	....do	....do	1	10.0	80
Do	....do	....do	Flour- and grist-	3	40.0	34
Do	....do	....do	Saw	2	28.0	19
Do	....do	....do	Cotton-gin	1	20.0	10
Do	....do	....do	Cotton-mill	1	50.0	75
Do	....do	Lincoln	Flour- and grist-	6	71.5	60
Do	....do	....do	Saw	4	38.0	33
Do	....do	....do	Woolen	1	....	12
Do	....do	Catawba	Flour- and grist-	7	125.0	110
Do	....do	....do	Saw	3	34.0	30
Do	....do	....do	Miscellaneous	3	45.0	23
Do	....do	Alexander	Flour- and grist-	10	115.0	153
Do	....do	....do	Saw	4	58.0	62
Do	....do	....do	Cotton-factory	1	13.0	30
Do	....do	Caldwell	Flour- and grist-	13	250.0	157
Do	....do	....do	Saw	7	104.0	155
Do	....do	....do	Woolen	1	6.0	....
Do	....do	....do	Cotton-mill	1	48.0	120
Do	....do	Burke	Flour- and grist-	13	213+	255
Do	....do	....do	Saw	4	60+	55
Do	....do	....do	Woolen	2	16.0	28
Do	....do	McDowell	Flour- and grist-	9	133.0	92
Do	....do	....do	Woolen	2	16+	20

CHAPTER X.

THE BROAD RIVER AND TRIBUTARIES.[1]

THE BROAD RIVER.

Broad river takes its rise on the eastern slope of the Blue Ridge near Hickory-nut gap, in the southwestern part of McDowell county and the northeastern part of Henderson county, and after flowing in a general southeasterly direction through Rutherford county and a corner of Cleveland county, North Carolina, and in South Carolina between the counties of York, Chester, Fairfield, and Richland on its left, and Spartanburgh, Union, Newberry and Lexington on its right, it unites with the Saluda river just above Columbia to form the Congaree. The length from source to mouth, measured in a straight line, is about 128 miles, but following the course of the river it is very considerably greater. There are no towns of any importance on the river.

The Broad river drains a total area of about 4950 square miles, of which 3550 are in South Carolina and 1400 in North Carolina. The important tributaries in North Carolina are as follows: Green river, draining an area of 198 square miles, First Broad river, draining 302 squares miles, and Second Broad river, draining 193 square miles.

The general character of the drainage basin resembles that of the Catawba. It lies entirely above the fall line; is well wooded, especially in the upper parts; is without lakes; affords fine building stone in numerous localities; and as regards soil, etc., is similar to the valley of the Catawba, the soil being generally loose and porous. The rainfall for the general basin of the Broad river may be given as follows: spring, 13; summer, 13; autumn, 10; winter, 15; total 51 inches. But the rainfall in the region about the headwaters of the river is probably much greater than this. The bed of the stream is rock, clay, sand, or gravel, and in many places the banks are low and the bottoms overflowed in freshets. The declivity of the stream is less than that of the Catawba, but still very large.

Daily readings of water height and occasional measurements of discharge have been made on this river since 1896, and these measurements and the computations from them will be found on pp. 319-322.

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[1] By Geo. F. Swain and J. A. Holmes.

The waterpowers on the Broad river may be described briefly as follows, starting at the South Carolina state line and proceeding up the stream:

Hopper and Blanton shoals.—One-fourth of a mile above the mouth of the First Broad river is the beginning of a horseshoe bend, convex eastward, which is two miles around, while the distance across the neck is about five hundred yards. This neck is low, rising about fifty feet above the river at the highest point. The fall has been roughly measured across this neck and is said to be between 25 and 30 feet. On the lower side of this neck there is a short shoal in the river known as the Hopper shoal; on its upper side there is a similar one known as Blanton shoal. There has been some talk of developing a power here by cutting a canal and tunnel across the neck of this bend and turning the river through this canal by constructing a dam across it just above Blanton shoal.

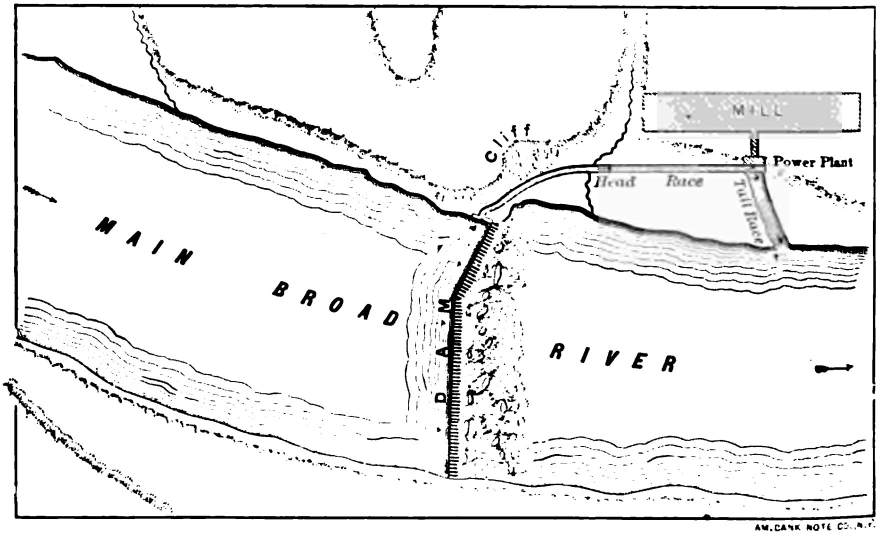

FIG. 15.—PLAN OF PROPOSED DEVELOPMENT AT DURHAM SHOAL MAIN BROAD RIVER.[1]

Palmer shoal.—This power is located just above Cleveland and Jollys ferry, one mile above the mouth of the first Broad river and about 7 miles below the mouth of Second Broad river. There is here a natural fall of about 18 feet in a distance of half a mile. The rock cliff is almost continuous on the north side, but the south bank is lower and nearly level.

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[1] Figs. 15 and 16 are reproduced through the courtesy of Messrs. Ladshaw & Ladshaw, of Spartanburg, S. C., who planned the constructions and furnished drawings from which these plates were made.

A grist-, saw-mill and cotton-gin were once operated here by throwing up a loose rock wing-dam about 4½ feet high and 600 feet long, extending out about two-thirds the width of the river and turning the current to the south side. There was a fall of 7 feet at the wheel.

DURHAM SHOAL is located one mile above Palmers shoal, 6 miles below the mouth of Second Broad river, and 6 or 7 miles from the nearest points on the Seaboard Air Line and Ohio River and Charleston railroads. The shoal is formed by a ledge of granite about 100 yards wide extending directly across the river, which would form an excellent foundation for a dam. The natural fall here is 7 feet, with favorable conditions for the erection of a dam that will increase the fall to 12 feet. The north (left) bank affords good building sites just below the shoal. Arrangements for the development of this excellent power are now being made by J. Y. Hamrick and others (see fig. 15, p. 224, for proposed development).

The next shoal on the river is an unimproved site located below Island ford and not far above the mouth of the Second Broad. There is said to be a small shoal about one mile below the same ford. In the absence of definite information concerning these two shoals they can only be mentioned here.

One and one-half miles below Poor's ford, and two and one-half to three miles above Big Island ford, there is a shoal said to have a natural fall of three feet and good rock beds and banks, upon which a dam could be safely and easily constructed.

At BIG ISLAND FORD SHOAL the larger part of the water flows on the south side of the river, and between the south bank and the island, in a distance of about one-fourth of a mile, there is said to be a fall of 8 feet; but this estimate is probably too high.

Above Island ford there are a number of small shoals on Broad river and its upper tributaries in Rutherford county, some of which could be developed into valuable powers, and a few of which are already utilized for grist- and saw-mills. The shoals on Green river will be described briefly below (p. 229).

TRIBUTARIES OF BROAD RIVER.

FIRST BROAD RIVER.

This tributary stream rises in the extreme northern part of Cleveland and Rutherford counties and flows south through the former, passing within three miles of Shelby, joining the main Broad river a mile below Palmers shoal. It drains an area of 302 square miles, and its fall from the crossing of the railroad from Shelby to Rutherfordton to the mouth of the stream is about 105 feet, or at the rate of 8 feet or more per mile. The width of the stream at its mouth is about 90 feet.

The powers on the river in their order ascending are as follows:

The **Buck McSwain shoal** is located about one mile above the mouth of the river. It has a natural fall of about three feet in 150 yards. The bottom is of solid rock with a sandy bank on the east side and a clay hillside on the west.

Stices shoal, located, following the course of the stream, about four miles above its mouth, two and one-half miles from Pattersons, on the Ohio river and Charleston railroad, and about five miles southwest of Shelby, on the Seaboard Air Line railroad. The shoal has a natural fall of 6 feet in a distance of 80 feet over a smooth rock bed, and below this there is said to be about the same amount of fall in a distance of 200 yards. By the construction of a dam across this upper part of the shoal this fall could be still further increased. This excellent power belongs to Dr. R. H. Morrison of Shelby. It was used during the Civil War to operate iron-works, and had been utilized for half a century before that time for grist- and saw-mills, but it is now unoccupied.

At **Chambers' grist-mill** there is a fall of 9 feet, though it is said that a fall of 15 feet is available. The stream is almost as large here as at its mouth, and will probably afford 7 to 8 horsepower per foot fall in the low season of dry years, 9 or 10 in the low season of ordinary years, and 20 to 25 for nine months.

The **Lauraglen cotton-mill** occupies the next site on the river above Chambers, situated three miles southwest of Shelby. This factory contains 3500 spindles and is operated entirely by waterpower. The dam here is 14 feet high and 200 feet long, and the fall of water at the mill is 15 feet.

Double shoals, the next important power on the river, is the site of the cotton-factory known as the Double Shoals mill, about eight miles north of Shelby and four miles east of the Cleveland mills. It contains 2000 spindles, run by waterpower alone. The dam is 9 feet high, and the water falls 15 feet at the mill.

Cleveland cotton-mill No. 2 is also located on this stream ten miles north of Shelby and three miles north of the Double shoals. This mill contains 4224 spindles, run by waterpower exclusively. The dam is 12 feet high and 270 feet long, and the fall of water at the factory is 13 feet.

There are other small shoals on this stream both above and below the Cleveland mill, some of which are utilized for grist- and saw-mills, and some of them undeveloped, but the information concerning them is too incomplete to permit of their being described in this report.

On *Knob creek*, a small tributary stream which joins the First

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Broad at Gardners ford, is situated the CLEVELAND MILL No. 1, twelve miles north of Shelby. This factory contains 884 spindles, run by waterpower alone. The dam is 15 feet high and 90 feet long, and the fall is 15 feet at the factory.

SECOND BROAD RIVER.

This river, the next tributary worth mentioning, rises in McDowell county and flows through Rutherford county, draining an area of 193 square miles. It is a small stream, only thirty feet wide at its mouth, but there are several good powers on it.

TUMBLING SHOAL, three miles from the mouth of the river, not now used, is the first, and a fall of 11 feet with good building sites can be obtained here in a distance of 200 yards. The stream would probably give from 4½ to 5 horsepower per foot of fall in the low seasons of dry years.

HIGH SHOALS, on which is located HENRIETTA COTTON-MILL No. 1, is four miles above the mouth of the river and one mile above Tumbling shoal. A branch road connects the place with the Seaboard Air Line railroad. The original shoal had a fall of 23.4 feet, over a narrow and rough rocky bed, in a distance of about 800 feet. The dam is of stone curving slightly up the stream, 200 feet long and 17.8 feet high, with an 18-foot base and 5-foot coping. It is pierced by 3 waste ways having an area of 12 square feet each, for use in drawing down the pond. The race is 300 feet long, 35 feet wide and 10 feet deep, giving a fall of water at the wheel of 32 feet, the power being generated by two pairs of twin turbines mounted on horizontal shafts and located 16 feet and 3 inches above the surface of the water in the tail-race. The mill contains 25,000 spindles and 1000 looms (see fig. 16, p. 228, for the plan of development of this mill).

The HENRIETTA MILL No. 2 occupies the next two shoals about two miles above High shoal, formerly known as Harrell's and the old "Burnt factory" shoals, the two having a total natural fall of 18 feet. The dam is placed on the lower shoal and backs water over the upper, giving a fall of 29 feet at the wheel. This mill contains 35,000 spindles and 1000 looms. A branch of the Seaboard Air Line railroad is now in operation to these mills.

SETTLEMEYERS SHOAL is situated on Sandy Run creek about one mile above its confluence with the main Broad river and about six miles from Mooresboro on the Ohio River and Charleston and Seaboard Air Line railroads. The shoal is utilized to operate a grist- and saw-mill and a cotton-gin, using about 80 horsepower under a head of ten feet, which can be increased to 25 feet.

On other smaller or less important streams tributary to Broad river in this region are numerous small powers, some of which are utilized in running grist- and saw-mills, while many of them are as yet undeveloped.

On *Buffalo creek*, near where it is crossed by the Seaboard Air Line railroad, is a small cotton-mill containing 3000 spindles, operated by the Buffalo Manufacturing Company, run entirely by waterpower. The dam here is 90 feet long and 25 feet high, giving a fall of 30 feet at the wheel. Below this and just above the mouth of Muddy Fork creek, at the site of the old Roberts forge, there is said to be a good power. About two miles above the cotton-mill is Beams grist-mill, and three or four miles above this latter is Bakers grist-mill.

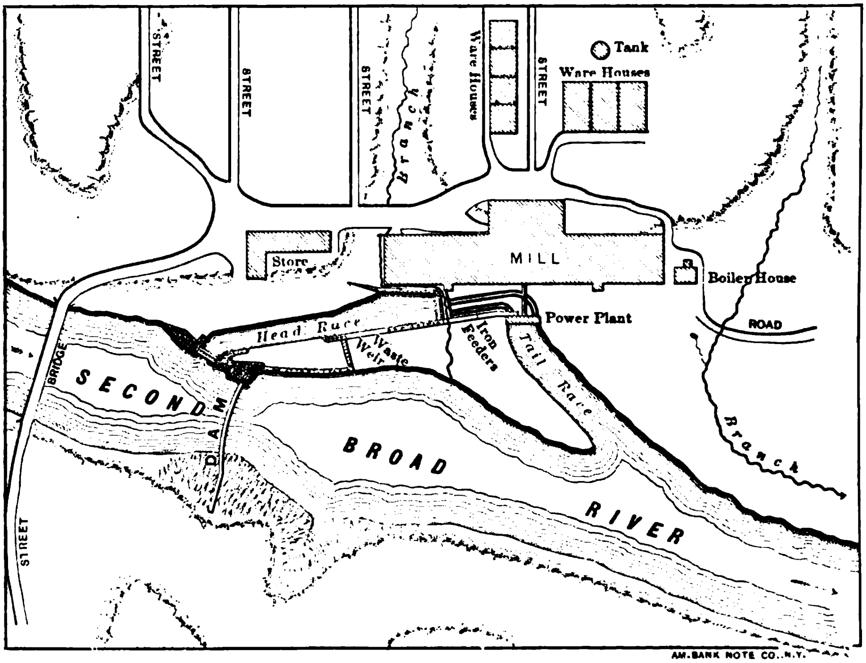

FIG. 16.—PLAN OF DEVELOPMENT AT HENRIETTA COTTON-MILL, No. 1, SECOND BROAD RIVER.[1]

On *Muddy fork*, a tributary to Buffalo creek, there is said to be, about one mile above its mouth, an excellent small unimproved shoal, with a fall of 20 feet in 200 yards, which is said to be capable of yielding 40 horsepower in dry weather.

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[1] Figs. 15 and 16 are reproduced through the courtesy of Messrs. Ladshaw & Ladshaw, Spartanburg, S. C., who planned the constructions and furnished the drawings from which the plates were made.

Quinn & Harrell's mills.—Wheat, corn and saw, 2 turbine-wheels, 32 inches and 28½ inches, and a Willis wheel for the saw-mill. 8 feet fall at the wheel, practically all given by the dam which is 8 feet high. Water flows off rapidly below and about one-fourth of the water used when all the machinery is running. This site is two miles over good road from the Ohio River and Charleston railroad.

All these streams have, as a rule, rock beds and good banks, which are not often overflowed. They are subject to heavy but short freshets. The typical soil in all this region is a loam which becomes more clayey in some regions and sandy in others.

GREEN RIVER.

This, the last important tributary of the Broad, rises in the mountains of Henderson county and flows a little north of east into Polk county where it joins the Broad. The upper part of its course lies in a narrow valley not over four miles wide for over twenty miles from the head of the stream, but below that the basin is much wider. The length of the stream in a straight line is about 36 miles and its drainage area about 188 square miles. It has a rapid fall and considerable power is available, though very little is used. The bed is rock, and the banks in some places are nearly vertical rock walls, while at others the river winds through fertile bottoms, subject at times though not extensively, to overflow, these bottoms being specially frequent in the lower part of its course. The stream is very inaccessible, being crossed by only one railroad—the Spartanburg and Asheville branch of the Southern railroad—about 16 miles from its head. The stream is about 100 feet wide where this road crosses it and about 90 feet wide at its mouth.

We obtained information regarding three shoals on the stream, but on account of the rapid fall there are doubtless other places where power could be obtained by damming. The lowest point is at Green river cove, where there is said to be considerable fall, not utilized, extending over some distance. This site is at a considerable distance from the railroad and not easily accessible.

Pot shoal, which is just below the railroad crossing, is much more favorable, and is said to be the best site on the river. The falls commence just below the bridge and continue for some distance, the fall being very rapid, with now and then an abrupt fall of several feet. The bed is solid rock and the banks generally high, but near the foot of the shoal there is said to be a very good building site. The shoal takes its name from a number of curiously worn-out holes ("pot-holes") in the rock forming the bed of the stream, almost circular, and looking very much like large auger holes.

About two miles above the railroad and, therefore, not so favorably located as Pot shoal, are the "FALLS" OF THE GREEN RIVER, the third site above referred to and the only one visited in person. The fall is about 30 feet in 100, preceded by rapids for three-eighths of a mile, making a total fall of 45 feet. The banks are rocky and very steep, so that building facilities are not good. The drainage area above this place is 67 square miles and the available power would perhaps be one horsepower per foot in the low season of dry years and 3½ to 4 horsepower per foot for nine months of an ordinary year. The building facilities at Pot shoal are said to be much better than at these "falls," and the fall is also said to be greater.

The First and Second Broad rivers are crossed by the Carolina Central and the Ohio river and Charleston railroads, and the Green river is crossed by the Asheville and Spartanburg division of the Southern. Still, some of the best waterpowers in this region are so far from railroad transportation that it will be cheaper in their development to transmit by electricity the power for factories located on railway lines.

TABLE OF UTILIZED POWER ON BROAD RIVER AND TRIBUTARIES.

Stream.	Tributary to what.	County.	Kind of mill.	No. of mills.	Total fall used.	Total horsepower used.
Broad	Congaree			....	......	.....
Tributaries of	Broad	Cleveland	Flour and grist	16	240.0	220
Do	do	do	Saw	10	179.0	147
Do	do	do	Cotton-gin	1	....	....
Do	do	do	Paper-mill	1	16.0	75
First Broad river	do	do	Cotton-factory	1	15.0	....
Do	do	do	do	1	15.0	....
Do	do	do	do	1	13.0	....
Second Broad	do	Rutherford	do	1	32.0	620
Do	do	do	do	1	29.0	....
Tributaries of	Second Broad	Cleveland	do	1	15.0	48
Do	do	do	do	..	...	....
Buffalo creek	Broad	do	do	1	30.0	....
Tributaries of	do	Polk	Flour and grist	1	23.0	35
Do	do	do	Saw	1	22.0	34
Do	do	Rutherford	Flour and grist	18	254.0	277
Do	do	do	Saw	4	....	45
Do	do	do	Woolen	1	12.0	4
Do	do	do	Leather	1	50.0	40
Do	do	do	Cotton-gin	1	12.0	30
Do	do	McDowell	Flour and grist	4	51.0	51

PART III

NOTES ON THE WATERPOWER IN NORTH CAROLINA WEST OF THE BLUE RIDGE

E. W. Myers, J. V. Lewis

WATERPOWER IN NORTH CAROLINA WEST OF THE BLUE RIDGE.

BY E. W. MYERS AND J. V. LEWIS.

INTRODUCTION.

No thorough examination of the streams and waterpowers of the mountain counties in North Carolina has yet been made. It is expected, however, that this will be undertaken by the State Geological Survey during the next two years. The data upon which the present paper is based were collected by the writers during a reconnoissance trip through the mountain counties in the summer of 1895. They visited all of the larger streams and many of their tributaries, and made numerous inquiries concerning the more inaccessible localities which were not examined by them in person. The estimates as to the fall in the various streams were based on measurements made with a Locke hand-level for short distances and an aneroid barometer for greater distances. All the gaugings of the streams north of Asheville were made by the use of a series of surface floats, ⅔ or ¾ of the surface velocity being taken as the mean velocity of the current, according to the stage of the water, whether high or low.

Of course it is not claimed that examinations of waterpowers made in this way are sufficiently accurate to serve as a basis for the investment of capital and development work. It was simply the best that could be done at the time, and the results obtained serve to indicate only where further investigations are needed, and where waterpower developments in future would probably prove successful. A series of more elaborate and accurate observations is already under way, and during the past three years on the French Broad at Asheville, the Tuckaseegee at Bryson City, the Little Tennessee at Judson (a few miles above its junction with the Tuckaseegee) and on the Hiwassee at Murphy, daily measurements have been made and recorded showing height of water in these streams at these stations, and occasional gaugings have been made to determine the velocity and volume of water in the streams at high, low and intermediate stages of water.

It is expected that this work will be continued for a number of years, and that additional gaugings will also be made at intervals on the streams to the north of Asheville in order that we may be able to determine with greater accuracy the volume of flow and the horsepower per foot fall at different points on these streams. It is also expected that during the next two years lines of levels will be run up all the larger of these streams in order that the fall at different points may be determined more accurately, and in this connection special examination will be made of the various shoals in these rivers, not only as to the fall of water within a given distance, but also as to the conditions, favorable or unfavorable, for the construction of dams and canals or races. Additional rainfall stations are also being established at different places in this mountain region in order that we may determine more accurately the amount of rainfall in each of the several river basins, but all of this work requires time, and its value increases almost in proportion to the number of years during which the records of river gaugings and rainfall extend.

Meanwhile, this preliminary statement is published in hope that information given may be of service in aiding intelligent development of additional powers and manufacturing enterprises in this region. A brief description of the geologic conditions influencing waterpower development in this mountain region is to be found on pages 86 to 88. One point of special interest mentioned there is that in these mountain streams the number of falls, and even the number of shoals occurring along the larger streams, is much smaller than might be expected under the circumstances. Instead of these, we have simply in large portions of these streams very rapid currents or a succession of rapids. The explanation of this condition of things is to be found in the fact that these streams have occupied their present channels for such long periods of time; and the great rapidity of their flow has enabled them to carry suspended in the water large quantities of sand and gravel and bowlders, and these have worn away the projecting masses of harder rock, keeping these more nearly on a level with the adjacent softer beds. This condition has been further facilitated by the comparative absence of such radical differences in the character of the beds of rock crossed by these streams as are described in the pages 86 to 88 referred to above. Hence, while these streams descend rapidly towards the lowlands, their descent has become in the course of time more or less uniform for considerable distances.

In the following pages the effort is made to indicate those points on the streams there considered where waterpower development has been made or is considered practicable, and the word "shoal" there used refers to this condition. The height given for the various shoals is in most cases that determined by hand-level from comparatively smooth water below the shoal to comparatively smooth water above, and, as a rule, takes no account of the fall in the smooth water above and below, although this may be large.

As the fall per mile on all these streams is so great, it was hard to decide definitely as to what constituted a shoal of sufficient importance to be noted here, so only those localities are mentioned where the fall in the stream is noticeably concentrated, even though the amount of fall thus concentrated may be small. Shoals of only a few inches fall usually indicate that a ledge of rock crosses the river at that point and the water flows over this in a miniature cascade. Such localities are noted more with reference to the possibilities for building dams and races than for the fall.

In the development of waterpower in this mountain region where, for the most part, the streams run as rapid currents through deep rocky channels, two general plans suggest themselves. One is the building of high stone dams—20, 50, or even 100 feet high—across these narrow, rocky gorges, the construction of wheel-pits at or near the dams, and the construction of power-houses immediately above the wheels (see Plate XV, p. 348). In this case, where there would either be no race at all or a short one, the fall of water would be practically the same as the height of the dam, the steep descent of the river channel below the dam securing the rapid removal of the water from beneath the wheel. The other plan which suggests itself is the construction of lower dams and the conveying of the water either through open canals or closed pipes for some distance along the banks of the stream until some point is reached where a sufficient fall can be obtained and the power-house constructed. As the conditions will vary at different points, so it may be found that one or the other of these plans, more or less modified, will be better adapted to the development work contemplated. Whether the dam constructed be a low or high one, the pond produced at most places will be comparatively small, and will be sooner or later filled with sediment brought down by the rapid streams above unless this is guarded against in the construction of the dam.

The majority of locations in this mountain region where waterpower developments are practicable are not within easy reach of transportation facilities over either railroads or good wagon-roads, and in many cases the gorges are so narrow and the country so rough that the conditions are not favorable to the establishment of adjacent manufacturing plants. Hence, in the development and utilization of these waterpowers, it would seem not only advisable, but necessary, that the power should be transmitted electrically from the places of development to points on the railroads where locations for the establishment of manufacturing plants and transportation facilities are both within easy reach. Fortunately, in this connection, the electric transmission of power is no longer a matter of experiment, but is now accepted as one of the most satisfactory and economic methods of both transmitting and distributing power, and this method of transmitting power is entirely practicable in the roughest and most rugged sections of country. A discussion of the advantages and methods of transmitting and distributing power in this way will be found on pages 337 to 350.

CHAPTER XI.

THE NEW, WATAUGA AND TOE RIVERS.[1]

NEW RIVER AND TRIBUTARIES.

New river rises on the northwest slope of the Blue Ridge in the southern part of Watauga county near Blowing Rock. Thence it flows in a general north-northeasterly course across the counties of Watauga and Ashe into Virginia. Over the larger part of its course in these two counties it is known as the South fork of New river, which will be described more fully further on. Just before reaching the Virginia line it is joined by the "North fork," which rises on the east slope of the Iron mountains along the southwest border of Ashe county. After crossing the line into Virginia the river follows an easterly course near the North Carolina line for a distance of about 12 miles, when it changes to a southeasterly course and crosses the North Carolina line and runs for a distance of 4 or 5 miles in Alleghany county. It then again crosses the state line into Virginia and flows in a general northerly course into the Kanawha and the Ohio.

In its course across Watauga and Ashe counties it is everywhere a rapid mountain stream, running for the greater part of this distance through narrow, rather deep gorges, with in many places a rocky bottom and rocky slopes, furnishing at numerous points conditions favorable for the construction of dams. The total drainage area of the North and South forks of New river above their junction in 631 square miles. Of this area, in 1880, 92,000 acres were reported as being in cultivation, 57,000 acres in grass and 240,000 acres, or 61 per cent. of the whole, were still forest-covered. The total rainfall of the basin as indicated by the records of a single station—that at Blowing Rock—which extends over a period of three years, is 49 inches for the year, distributed as follows: for the spring, 11.3; summer, 16.2; autumn, 9.7; winter, 11.8 inches. A considerable portion of the cleared land is in grass and is used for the pasturage of cattle. It is a fine country agriculturally, the soil being quite deep and for the most part a fertile, sandy and gravelly loam, and the lower part of the basin in Ashe county is rich in mineral deposits, including a number of large beds of high-grade magnetic iron ore and several fine copper properties. There are numerous tributary streams, on practically all of which, owing to the rapid descent of their basins, small waterpowers could be easily developed. Owing to the steepness of the mountain slopes, all of these streams are at times subject to freshets, and after hard freezes in the winter occasionally ice dams of considerable magnitude are formed, so that the stone dams constructed in connection with waterpower developments need to be built strongly and with considerable care in order to secure their permanency against the freshets and these ice dams.

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[1] By E. W. Myers and J. V. Lewis.

WATERPOWER ON NEW RIVER.

Nearly all of the shoals which are capable of being developed into waterpowers are to be found on the North and South forks of the river, and will be described under these headings further on. The lowest shoal on the main river in North Carolina which deserves mention here is that in the northern part of Ashe county where the river makes its bend into North Carolina. Here for a distance of about 4 miles the river is almost a continuous series of rapids, and is reported to contain a number of shoals which might be utilized, especially about Horse ford. In the lower portion of this section there is a natural fall of about 7 feet in a half mile, and the width of the river at the head of this shoal is about 350 or 400 feet with steep sloping bluffs on either side.

From where New river first crosses the North Carolina-Virginia line up to the junction of the North and South forks, a distance of about 4 miles, no shoal of importance was reported except the Blevins shoal, which is to be found just below the junction of the two forks. This shoal was not visited and no definite information concerning it could be obtained except that it is "a good shoal."

As will be seen on the map (Plate I, frontispiece) after crossing into Virginia near the northeast corner of Ashe county, New river again enters North Carolina, and remains in the northern central part of Alleghany county for a distance of 3 or 4 miles before turning northeastward again into Virginia.

TRIBUTARIES OF NEW RIVER.

The three tributaries on New river which deserve description in the present connection are the Little river and the North and South forks of New river.

LITTLE RIVER.

Little river rises on the north slope of the Blue Ridge in the southern part of Alleghany county and flows across this county in a northeasterly course until it reaches the Virginia line, and then it turns north-northwest and joins New river at a point three or four miles north of the state line. The stream is rapid throughout its entire course and at intervals its narrow gorge, with rocky bottom and sides, would be favorable for power development if the water supply were sufficient.

No information was obtainable concerning any important shoal or available mill site on this stream below the mouth of Brush creek; but we were informed that there is a fine fall all the way from this point to the Virginia line. Just below the mouth of Brush creek there is reported to be a good shoal, but no definite data in regard to the fall of water there and availability for power development were obtainable. There is also said to be a good power site, with a small natural fall between this point and the FENDER MILL above. This mill is one mile south of Edwards Cross-roads, and is situated on the north bank of the river. The shoal is formed by the water flowing over a ledge of granite which gives an almost perpendicular natural fall of about 5.5 feet. On top of this ledge there is a log dam three feet high. The mill is a combination corn-, wheat-, saw- and shingle-mill run with about half of the water available.

Just above and below the mouth of Bledsoes creek there are said to be one or more old mill sites capable of being developed into a good power. Above this, and two and a half miles southeast of Sparta, is a good power developed by a fourteen-foot wood dam, which now runs a saw-, flour-, grist- and carding-mill. Three miles above this, and one mile below Whitehead, is Joynes & Richardson's flouring-mill, the power to operate which is developed with a small natural fall and a ten-foot wood dam. One-half mile above this latter place there is said to be another good shoal. At Whitehead a saw-, flour- and grist-mill are operated by a fourteen-foot overshot wheel.

On Brush creek, one of the largest tributaries of Little river, there are said to be several important shoals, one on this creek just above its mouth and another several miles further up the stream near the mouth of Laurel creek.

NORTH FORK OF NEW RIVER.

North fork of New river, which rises near the Ashe-Watauga county line on the northern and eastern slope of the Iron mountains, flows as a rapid stream across Ashe county in a southeasterly course, joining the South fork a few miles before New river reaches the Virginia line. It has a total drainage area of 298 square miles, the upper portion of which is entirely forest-covered. On the northwest side it has three prominent tributaries, on each of which small waterpower developments are possible—*Helton creek*, with a drainage area of 47 square miles; *Horse creek*, with a drainage area of 58 square miles; with *Laurel fork* or Big

Laurel creek with a drainage area of 32 square miles. Its principal shoals, which are promising for small waterpower developments, are the following:

About two miles and a half above the junction of the two forks of New river and a mile above Weaversford is DIXON'S MILL (corn and wheat), with an eight-foot wood dam and a nine-foot working head. The dam is 212 feet long and rests on a rock foundation with solid rock abutment on the east bank. The rock rises into the hillside on the west bank at a distance of a few feet from the end of the present dam. The river is here quite rapid for 200 yards below the mill and the tail water flows off readily. A pit has been constructed for a turbine-wheel, but the small power used when the region was visited is developed by Willis wheels. It is estimated that over 300 horsepower could be obtained here at all seasons with the proper development. The property belongs to Mr. J. A. Dixon of Weaversford.

Two miles above Dixon's mill and a mile below the mouth of Helton creek is a shoal known as the FALLS, the property of the widow Plummer. The river at this point has a width of about 150 feet, and the shoal consists of heavy rock ledges which continue up the hills on either side at an inclination of about 40° on the east and about 25° on the west. The natural fall is three feet in about 600 or 800 feet, and there is a fall of about four feet in a quarter of a mile above the shoal. A dam fifty feet high could be built from rock on the spot; but there is little level space for building. The highest recorded water-mark was reached in September, 1878, and is about 18 feet above the ordinary water level.

About five miles above the "Falls," and just above the mouth of Silas creek, there is said to be a good available shoal with a satisfactory place for a dam, the bed and banks of the stream being of rock. This property is owned by P. Ballou and Calvin Brinegar.

For several miles above this latter point the stream is very rapid, and there are good mill sites at intervals of every two or three miles; but there are no shoals of much importance till we reach SHARPS SHOAL, which is about four miles above the mouth of Buffalo creek and opposite the northeastern extremity of Three Top mountain. The natural fall of this shoal is about 7.5 or 8 feet in a distance of about 200 feet. The river is about 70 feet wide at the head of the shoal, and there are good rock abutments on either side for a ten-foot dam. There is swift water below and plenty of good level ground for buildings. The rock is a hard, compact gneiss of almost granitic structure, and a high ledge up the hill to the north of the shoal will furnish great quantities of this material for foundations, dam, and other building purposes. Above this point no shoals of any considerable importance were observed or heard of.

SOUTH FORK OF NEW RIVER.

This fork of New river has already been briefly described (p. 237) as the upper portion of New river. Its drainage area above where it joins the North fork is 333 square miles. Its principal shoals and water-powers are as follows:

On the South fork, about three-quarters of a mile above the junction of the two branches of New river, is the WALLACE FORGE SHOAL, which has a natural fall of about three and a half feet in one thousand. There is an excellent rock foundation for a dam and solid rock bluffs in the hills on either side, rising at an angle of 40° to a height of 50 feet or more. The width of the river where dam would probably be built is 250 feet, and the current for some distance below the shoal is very rapid, having about two feet fall in the next 200 yards. There is no level space for building, though buildings could be placed near the foot of the shoal on gently-sloping hillside. There was once an old forge here with a wooden dam, but this was washed away about twenty years ago.

DOG CREEK SHOAL.—For the next twenty miles above the Wallace Forge shoal the river is as compared with other mountain streams, shoaly, rather sluggish, and in this distance no shoal with a natural fall that is worthy of special note was observed until near the mouth of Dog creek, which is about five miles east of Jefferson. Here there is a natural fall of about six feet in 350 to 400 yards, a good foundation for a dam and excellent grounds for buildings. The dam would necessarily be quite long, as there is a strip of bottom-land along the whole of the west side of the shoal.

About a mile above the mouth of Dog creek, and just above the mouth of Roans creek, is the old BOWERS MILL site, which is regarded as a good shoal.

The next shoal of importance, about a mile and a half above this, is the WITHERSPOON FORD SHOAL, just below a ford of that name. This has a natural fall of about 5 feet with good rock foundations and abutments for dam and abundant level building space.

About half a mile above Witherspoon ford, and a short distance above the mouth of Bear creek, is the YATES SHOAL, which is said to be a good site, but we did not see it and have no definite data concerning it. About two miles further up is the BRUSH CREEK SHOAL, of about the same character as the last-named, just above the mouth of Brush creek.

Two miles above this last-mentioned is TURTLE SHOAL, which has about 5 or 6 feet fall in 100 yards, but there is a broad level bottom on the left bank which would greatly interfere with building a substantial dam.

Roaring shoal is about two miles above the last-named and a mile and a half above the mouth of Obids creek. It has about the same fall as Turtle shoal, but there is no good building room.

Elk shoal is a mile and a half still higher up the South fork, and has a natural fall of about 10 or 11 feet in a short distance. It affords a good solid foundation for dam and has good rock abutments on the sides, but there is no level ground for building.

There are also said to be good shoals just below the mouth of Pine Swamp creek and about a mile above it, but of no considerable fall. About three-fourths of a mile below the mouth of Old Field creek there is a good short shoal having a natural fall of about four feet. This is an excellent dam site and there is plenty of available building room.

Three miles above this last, and just below the mouth of Mill creek, is **Rocky shoal**, with a natural fall of 4 feet in about 250 feet. A solid rock ledge runs across the river and up the hills on both sides, giving an excellent dam foundation. There is plenty of good building room at the foot of the shoal. A shoal very similar to the last, and said to be as favorably situated, is about three miles further up the river, just above the mouth of Grassy creek.

At Elk Cross-roads (Todd P. O.), and just above the mouth of Elk creek, there is a good rock shoal with steep, rocky banks on either side, suitable for building a dam forty or fifty feet high if necessary. For a mile above this the stream is very rapid and probably gives a fall of 15 or 20 feet. The whole of this distance is shut in by a rocky, narrow gorge. The water is also quite swift below the shoal.

For fifteen miles above this point there are no shoals or available mill sites. Half a mile below the mouth of Hardin creek and three miles east of Boone, a mill was being built at the time of our visit (1895). There is a small rapid with a good foundation for dam and rock abutment on the north side of the stream, but there is a broad meadow on the other bank. A brush dam about 4 feet high has been built, and a race dug in the soil about 800 feet long, giving a fall of about 8 feet at the wheel.

WATAUGA RIVER.

The Watauga river rises on the north slope of the Grandfather mountain and flows a distance of about 10 miles in a northeasterly course and then runs in a northwesterly course for a distance of something more than 20 miles before reaching the Tennessee line, where it flows through a deep gorge cut through the ridge of the Iron mountains. Its total drainage area above the Tennessee line is 162 square miles. Of this total area about 22,000 acres are cultivated, and about 12,000 acres are in grass, and 70,000 acres, or 67 per cent. of the whole, are still in forests. The soil is generally deep and open or porous, being usually a gravelly or sandy loam. The stream is everywhere a rapid one, and for a considerable portion of its course runs through a deep, narrow gorge with rocky bottom and rocky sides, furnishing at many points excellent facilities for the construction of dams.

The fall of the stream is very great throughout its length, and the selection of shoals for utilization becomes largely a matter of convenience. For several miles above the Tennessee line it flows in a deep gorge, and is practically a succession of rapids; along this portion of its course it is accessible in only a very few places. Between the Tennessee line and Shulls mill, a distance, following the course of the stream, of about 19 miles, the total fall in the river, as taken from the topographic map of the U. S. Geological Survey, is about 900 feet, and the average fall per mile is therefore about 47 feet.

The more important shoals of which there is information at hand are the following:

The first available shoal is about four miles above the state line, and above and below the mouth of Beech creek. Here is a fine site for dam and buildings; the fall could not be estimated, as the river is a series of rapids for long distances above and below the creek mouth, so that almost any desirable fall could be obtained.

About five miles further up, at the CALVIN WARD PLACE, just below the mouth of Laurel creek, there is a good mill and dam site with small natural fall.

One mile above this there is another good locality for a small mill. Rock ledges rise on either side for dam abutments, but there is very little concentrated natural fall, though the river is quite rapid. A small bottom affords plenty of level building room.

About two miles further up the river, just below the mouth of Cove creek, is a shoal with nine feet natural fall in 500 to 600 feet, with good abutments for a dam, almost perpendicular on one side and quite steep on the other. A fairly good building site is at the lower end of the shoal. About three feet of the fall is utilized by a small sawmill.

Six miles above the last-mentioned place, and just above the first ford above Valle Crucis, is a shoal with about 2 feet fall in 100 feet. Ledges of rock lie directly across the stream and extend up the hills on either side. A dam 14 or 15 feet high could easily be built, and there is plenty of room for buildings.

For four miles above this point the river is almost a continuous series of rapids and cascades in a deep gorge; and dams up to 60 or 70 feet high could be built in many places. But there is only an occasional narrow strip of bottom to afford building space.

A mile and a half above the mouth of Laurel creek there is a shoal with a fall of fifteen feet in about 150 feet. An excellent dam and building site with plenty of rock on the grounds for foundations and a dam.

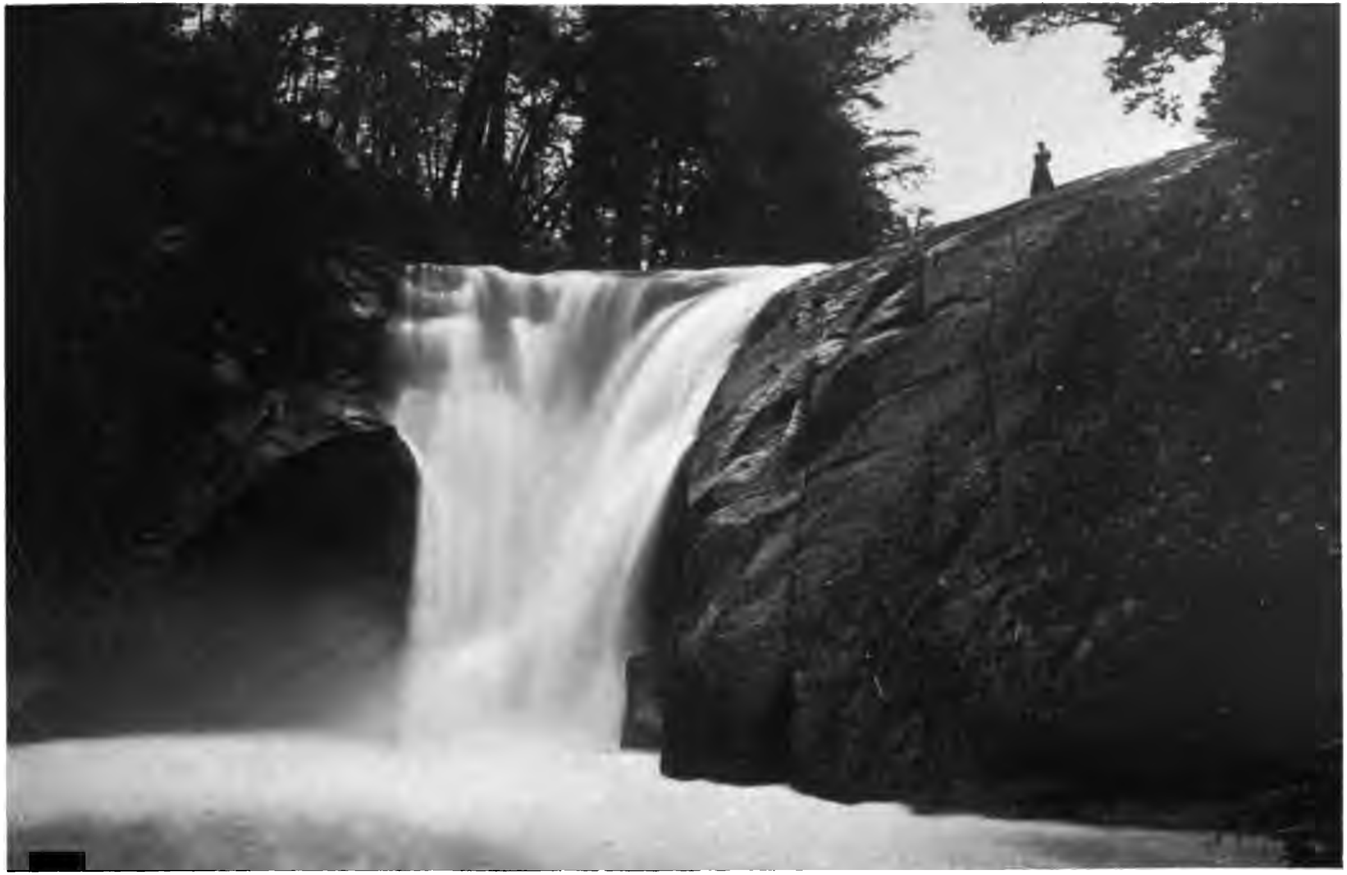
A single discharge measurement of the Watauga was made just below the mouth of Cove creek, showing a discharge of about 68 cubic feet per second, equivalent to 7.7 horsepower per foot of fall.

The Watauga river receives as tributaries several large creeks, of which Cove creek (draining 41 square miles) and Beaverdam creek, entering from the north, and Elk creek (draining 47 square miles) from the south are the principal ones. On Cove and Beaverdam creeks the fall is very large, and though the quantity of water is small, there are numerous small powers on them, some of which are used to operate the small saw-mills and grist-mills which supply the local needs.

The most noteworthy power on any of these tributary streams is ELK FALLS (Plate XI), located on *Elk creek,* just above the Mitchell-Watauga county-line. Here there is a sheer jump of from 26 to 28 feet, and from the top of this fall there is a fall of 85 feet in one mile, then for four miles the fall will average 100 feet per mile. Above Elk falls there are numerous small shoals and rapids as high up as Banners Elk, giving small compact powers of from 20 to 40 feet fall.

TOE RIVER AND TRIBUTARIES.

This river, which in North Carolina has its tributaries mainly in the counties of Mitchell and Yancey, and flows thence into Tennessee, is in the latter state known as the Nolechucky; and in North Carolina this same designation is sometimes applied up to the junction of the North and South Toe rivers, about 5 miles east of Burnsville. It is more generally called Toe river throughout its entire course in North Carolina. It rises in the extreme northeastern portion of Mitchell county between Cranberry and Grandfather mountain, and flows thence for a distance of nearly 30 miles in a southerly course. It then flows westerly for a distance of some 15 miles to where it is joined by the South Toe river. Thence it flows north for a distance of 10 miles, where it is joined by Cane creek near Bakersville, and then runs in a deep, rocky channel west-northwesterly for a distance of some 20 miles to where it cuts through the mountains and flows out into the valley of east Tennessee, joining successively the French Broad, Holston and Tennessee rivers. Its total drainage area above the Tennessee line is 640 square miles, of which about 67,000 acres are in cultivation, 21,000 in grass, and 331,-



ELK FALLS, ON ELK CREEK, MITCHELL COUNTY

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000 acres, or 78 per cent. of the whole, still forest-covered. The total rainfall of this region is 51.2 inches for the year, divided as follows: spring, 11.4; summer, 15.7; autumn, 11.6; winter, 12.5 inches. The soil is deep, porous and fertile. The grasses grow vigorously on the cleared lands, and the cattle industry is quite an important one. The principal crops grown are corn and small grains such as wheat, oats and rye. At Cranberry and at a number of other points along the Iron mountain range are valuable magnetic iron ore deposits, and in both Mitchell and Yancey counties there are numerous mica deposits which are considered the most valuable in the United States. A projected and partly built railroad follows the course of the river for some miles both above and below the Tennessee state line, and when completed this will render many of these latent waterpowers accessible.

The more important tributaries are Caney river and North Toe on the south, Big Rock creek and Cane creek on the north. The stream is a rapid one throughout almost its entire course, and in many places it runs through a deep, rocky gorge, where the construction of dams for waterpower could be easily accomplished. There are occasional high freshets during which the water rises and goes down quite rapidly, and at rarer intervals in the early spring there is some little trouble from the breaking up of the ice, which, moving down the streams, forms temporary dams, but this is nothing like so serious as in the more northern states.

WATERPOWER ON TOE RIVER.

The more important shoals on this river are as follows:

One and one-half miles below the mouth of Caney river there are rock cliffs on either side of the gorge, here about 200 feet wide. The current is very swift, and there is a fall of 25 feet in about half a mile. There is a small building space about one-fourth of a mile below the best location for a dam.

In all this lower portion of the river the water is quite swift, and there are several places where dams might be built, but there is very little space for building on the banks, and for much of the distance it would be difficult to construct races in the rocky slopes.

Just above the ford, a mile above the mouth of Pigeon-roost creek, there is a good foundation for a dam and rock abutment on the north side, an island lying south of the main part of the stream about 15 feet high, which is never overflowed. A 5-foot dam here would raise the water at this point about to the level of the water at the upper end of the island, and a 6-foot dam across the narrow channel south of the island (50-75 feet wide) would allow a dam 10 feet high on the shoal in the main channel. A strip of bottom of about 15 acres affords ample space for buildings just below the shoal.

A gauging of Toe river was made about one mile above the mouth of Pigeon-roost creek (one-half mile above Relief post-office) when the water was about 6 inches above normal height. This showed the flow at that time to be 785 cubic feet per second, which is equivalent to about 89 horsepower per foot fall. Average surface velocity, 1.75 feet per second. Taking two-thirds of this (1.16) as the normal velocity, and 505 square feet as the normal cross-section, the normal discharge is 586 cubic feet per second, which gives 66.6 horsepower per foot fall.

One and one-half miles above the mouth of Pigeon-roost creek there is a good shoal with a natural fall of 6 feet in 300, and a width of about 175 feet. A rocky ledge crosses the river and extends up the bluffs on both sides, that on the south side rising some 40 feet back from the bank of the stream, at an angle of 30°, to a height of more than 100 feet. The north side is steeper and about the same height. There is a small level space on both banks about 200 yards below. There are no mills on the river above the Tennessee line except those named below, but there are several on the creeks. There is a considerable fall in the river all the way from the mouth of South Toe to the Deaton Bend (just above the mouth of Cane creek). Below Cane creek the river is very rapid, having 30 or 40 feet natural fall to the mile, with rock bottom all the way with steep, rocky sides to the gorge. There is practically no level building room except a narrow strip of bottom on the north side, half a mile below Cane creek. If a race were constructed on the side of the gorge it would pass through solid rock all the way—mostly dark, fine-grained basic massive rock.

Just below the mouth of Bear creek is John Bailey's grist-, saw- and mica-mill. This is a good site for a dam.

Two miles above Bear creek there is a coniderable fall in the "Narrows," just below where the road leaves the river.

Just below the bridge near Spruce Pine there was a mill, now washed away. There is a small shoal here, but no rock ledges crossing the stream or outcropping on the banks, which would serve to secure a dam.

Three miles below Wiseman's mill is Joseph Lovin's grist-mill.

Two miles below Three-mile creek is Lafayette Wiseman's mill. This was formerly a saw-mill and a corn- and wheat-mill, but the saw-mill has been washed away. There is a rock abutment on either side of the river and a shoal extends half way across, but there is little natural fall. The dirt side of the river bank has been washed out, but it is now walled in with rock.

Just below Three-mile creek (Elsie post-office) are Jas. H. Wiseman's saw-, wheat-, and corn-mills and wool cards.

A quarter of a mile below Plum Tree there is a mica-mill (H. R. Jones) which is operated by water conveyed in a ditch three-eighths of a mile long, the water being taken out of the river above the mouth of Plum Tree creek.

Three-fourths of a mile below Hensons creek (marked "Powder Mill creek" on the U. S. Geological Survey topographic map) there is said to be a good site for a dam.

Just above the mouth of Roaring creek there is a good rock shoal and sides for a dam with a natural fall of 4 or 5 feet reported.

TRIBUTARIES OF TOE RIVER.

CANEY RIVER.

The first of the important tributaries above the Tennessee line is Caney river, which rises on the western slope of the Black mountains in the southern part of Yancey county and flows in a general northerly course for a distance of some 20 miles to where it joins the Toe river, about 5 miles above the state line. Its drainage area is about 158 square miles. It is everywhere a rapid stream, and through a considerable portion of its course runs through a deep, narrow, rock-bound gorge, where the construction of dams for waterpower development would be an easy matter. While the stream is everywhere a rapid one there are but few shoals with concentrated fall to be found.

A gauging of the river was made about 1½ miles above its mouth at a point where the stream was about 200 feet wide, at a time when the water was said to be about three inches above its normal height. The result showed a flow of 511 cubic feet per second, which would indicate at this stage of water and place about 57 horsepower per foot fall. This gauging was made the morning after a very hard rain when the water was very turbid and is manifestly a high-water measurement, the discharge of 3.4 second feet per square mile being entirely too large for any normal stage of flow. The average dry season flow will probably be about 150 cubic feet per second and 17 horsepower per foot fall. The few shoals on this stream which may be considered suitable for waterpower development are described below.

About 5 miles above the mouth of the river there is a shoal with a natural fall of 5 feet in a distance of 200 yards, with a suitable place, with rock bed and sides, for a dam at the head of the shoal. The distance between the rocky banks on the opposite sides of the stream is about 150 feet. At the lower end of the shoal there is a small space suitable for buildings.

Just above the mouth of Bald Mountain creek there is a shoal with about 10 or 12 feet fall in a quarter of a mile with a number of good locations with good stone foundations for a dam and ample supplies of rock suitable for its construction. The walls of the gorge in which the river runs here have a slope of about 30°. The total length of the shoal, paced, is 1250 feet. The fall was estimated with hand-level and aneroid. On the south side of the river, about 200 yards below the foot of the fall, there is a small level area suitable for buildings. This shoal is the property of Jacob Lewis, Bee Log, N. C.

Still further above Bald Mountain creek, and about one and one-half miles below Higgins and Brown's grist- and saw-mill, there is a natural fall of 4 feet in a distance of 200 feet, with a suitable place for a dam a short distance from the top of the rapids. The bed of the stream at this point is of rock, and the rocky walls of the gorge are quite steep, having a slope of about 40° to a height of over 100 feet. There is about 3 feet fall through a narrow gorge for the next 300 yards, then there is a small space for buildings.

About half a mile above the last-mentioned, and a mile below Higgins and Brown's mill, there is a fall of 5 feet in about 250 yards with a good place for a dam about half way.

At Higgins and Brown's saw- and grist-mill, some 7 miles below Caney river post-office (following the river), there is a dam 4 feet high or less with good rock foundations and abutments, the width of the shoal being about 75 feet. There is here an excellent site for a dam, but the space for buildings is not extensive.

About 7 miles below Caney river post-office there is a four-foot fall in about 200 yards. The river is 50 feet wide with good rock shoal and steep rocks up both sides to a height of about 200 feet. There is some building space at the ford 200 yards below.

At the next ford above this last, one mile below Elk Shoal creek, there is a fairly good place for the location of a dam, and there is ample space for building room in the bend.

SOUTH TOE RIVER.

This stream rises at the extreme southern point of Yancey county between the Black mountains on the west and the Blue Ridge mountains on the east, and near where they join at the High Pinnacle. It flows in a general northerly course, and joins the North Toe river about 5 miles east of Burnsville. Its total drainage area is about 91 square miles, of which probably more than 90 per cent. is forest-covered. The few shoals worthy of mention on this stream are briefly described as follows:

About two miles below the mouth of Browns creek and 4 miles (straight line) above the mouth of the river, between Fawn Knob and

Celos Ridge, there is a shoal with a fall of 3½ feet in 100 feet over a ledge of coarse granite (pegmatite). The rock rises at an angle of about 15° on both sides (somewhat steeper on the south side). The width of the stream at the head of the shoal is 50 feet, but it is only about 15 feet wide at the narrowest place. There is ample level space for buildings on the south side just below shoal.

There is also a small shoal just above the mouth of Browns creek.

A short distance below the mouth of White Oak creek there is a shoal with a fall of about 4 feet in a distance of 300 feet. A ledge of solid rock crosses the bed of the stream, but this rock is not exposed in the banks for abutments, and the stream is here bordered by broad bottom-lands.

There is a small shoal between the last-mentioned and the mouth of Locust creek, and at the mouth of Locust creek is another small shoal with a fall of about 3 feet with good rock foundation for a dam.

Again, about one-half mile above the mouth of Locust creek, there is a fall of about 5 feet in a distance of 100 feet, with bottom and banks to the height of 10 feet solid rock.

There are almost continuous rapids in the bend below Colberts creek about 2 miles above Locust and 4 miles above Browns creek. In a steep, rocky gorge the stream flows as a continuous rapid, having a fall of 6 feet in 200 yards, the width of the stream being about 75 feet. There is an excellent site for a dam, with solid foundations and sides.

There is another small shoal about 200 yards above this mentioned at the mouth of Colberts creek, where there is a nearly perpendicular fall of 3 feet. The stream is here only 30 feet wide, but a dam 60 feet long would be required to develop this power fully.

Two smaller tributary streams may be mentioned: *Big Rock creek*, which rises on the southern slopes of the Iron mountains and just west of Roan mountain in the northwestern portion of Mitchell county, and flows in a southwesterly course, joining Toe river about 7 miles west of Bakersville, has along its course several small shoals, one or two of which have been already partially developed, and at one point, a short distance above its junction with Toe river, there is said to be a natural fall of 10 feet, which, with a dam, could be greatly increased.

Cane creek, which rises on the south side of Roan mountain and flows westward for a distance of about 10 miles, joins Toe river about 3 miles west of Bakersville. For one or more miles above its junction with the river it runs in a deep, narrow gorge with rocky sides, and is said to have a fall of more than 60 feet in a distance of less than a quarter of a mile.

CHAPTER XII.

THE FRENCH BROAD AND PIGEON RIVERS.[1]

THE FRENCH BROAD RIVER AND TRIBUTARIES.

The French Broad river rises on the eastern slope of Tennessee Ridge which lies between Jackson and Transylvania counties, and flows in a general northeasterly course across Transylvania and Henderson counties for a distance of about 30 miles, and thence northward across Buncombe county for a distance of something more than 20 miles; thence across Madison county for a distance of 20 miles, across Great Smoky mountains at Paint Rock into eastern Tennessee, where it joins the Nolechucky, the Holston and the Tennessee, flowing thence into the Mississippi and the Gulf.

The drainage area of the river above Asheville is 987 square miles, and the total drainage area in North Carolina is 1745 square miles. Of this, according to the statistics of the tenth census (1880) at that time, 191,000 acres were in cultivation, 41,000 acres in grass and 879,000 acres, or 78 per cent. of the whole, were still forest-covered. The total annual rainfall of this basin as represented by the station at Asheville is 42.6 inches, distributed as follows: spring, 11.7; summer, 13.8; autumn, 7.7; winter, 9.4 inches. The soil of the entire basin is deep and fertile, and is generally loose and porous, being a sandy and gravelly loam. The lands along the valley of the French Broad in Transylvania and Henderson counties are among the finest in the state. Through Buncombe and Madison counties the river for the most part runs through a deep gorge with but little land bordering it which can be cultivated, but on the hills back from the river there are many cultivated acres which yield abundant crops of tobacco, corn, wheat, oats and rye. Throughout the upper portion of the stream, while the current is not sluggish as compared with streams in the coastal plain region, it is not rapid as compared with other mountain streams. Its descent is fairly uniform, and no waterpowers have been developed, nor are the conditions there favorable for waterpower development. At a few places, however, where the river passes through a narrow, rock-bound gorge, permanent dams could be easily constructed which would yield

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[1] By E. W. Myers and J. V. Lewis.

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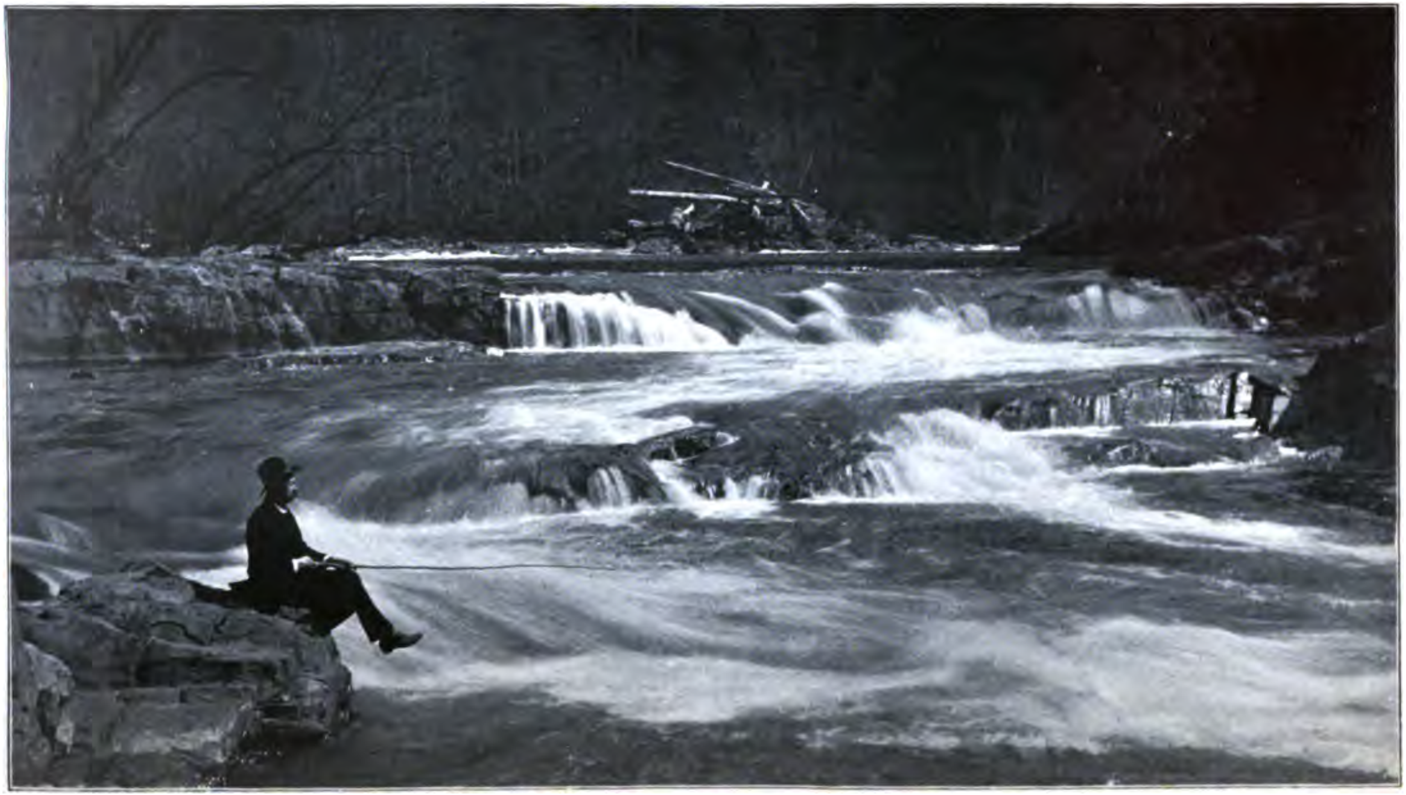

MOUNTAIN ISLAND SHOAL, FRENCH BROAD RIVER waterpowers of considerable magnitude. From Asheville to Paint Rock the river flows as a rapid current for the entire distance in a rocky gorge, the depth of which increases as the Tennessee line is approached, where the river makes its way across the Smoky Mountain ridge.

For measurements of the flow of the French Broad river at Asheville see pp. 322-326.

WATERPOWER ON THE FRENCH BROAD RIVER.

The total descent of the river from Asheville to Paint Rock is 710 feet. While this descent is fairly uniform, yet at several places there are shoals of greater or less prominence. A serious difficulty in the way of developing these shoals into waterpowers is that throughout this distance the river is closely followed by the Western North Carolina division of the Southern Railway, the track being for the most part only a few feet above high water. The more prominent of these shoals are the following:

From the Tennessee line up to Hot Springs, a distance of about 6 miles, the total fall in the river is 59 feet, an average fall of 9.8 feet per mile. This fall is well distributed, the river being smooth, running between stretches of bottom-land and having no shoals worthy of mention.

The first shoal on the river is a small shoal just above the bridge across the river at Hot Springs. The shoal has but small fall and is of no importance.

Above Hot Springs the character of the river changes abruptly. From a smooth, though rapid, stream it suddenly becomes a dashing mountain torrent, running between high hills on either side, its bed obstructed by ledges of rock that project in jagged ridges across the stream. There are also several small islands and large numbers of huge boulders, and in places the river becomes very wide. In the 7.7 miles between Hot Springs and the mouth of Brush creek the fall is 201 feet, an average fall of 26.1 feet to the mile, and this may be called practically one shoal. At intervals, however, the fall within this distance is much more concentrated, and there is even one short space where the water appears sluggish, just below Mountain island. Here the river contracts, just below the lower end of the island, to a width of not more than 60 feet, and the water is said to be 60 feet deep.

Mountain Island shoal is the first shoal on the river possessing any concentrated fall. Here there is a small rapid at the lower end of the island and an almost vertical plunge at the upper end of about 4 feet. There is also a small amount of land suitable for the erection of buildings at the lower end of the island (Plate XII).

From the upper end of the island to the mouth of Brush creek the river is a continuous rapid, but with concentration of fall about as follows:

About two miles above Mountain island, just below the mouth of Big Laurel creek and for about half a mile above its mouth, there is a large fall, estimated by eye alone as 15 feet or more in the half mile above the creek mouth. There is very little level ground bordering this part of the river, but situations suitable for buildings might be found at Frisby station, where also a good dam site may be found.

For the next mile the fall is large but well distributed, there being only two small shoals noticeable in this distance.

There is a long rapid, with large fall in the bend of the river, about 2 miles below Barnard. The aggregate fall here is not known. There is but very little room suitably situated for buildings.

Below, and extending for some distance above the mouth of Brush creek, the bed of the river seems to be of solid rock for a quarter of a mile; the fall is large, the banks rocky and very steep, and the river is narrow. The conditions for the construction of a dam are very favorable, plenty of building material being found on the spot. No ordinary development of any of these powers is possible, while the railroad track retains its present position, quite close to the river and only a few feet above the high-water level.

From the mouth of Brush creek to Asheville, a distance of 29.3 miles, the stream is still very rapid, but the average fall per mile is much less than in the section of the river from Brush creek to Hot Springs. The total fall from Brush creek to Asheville is 450 feet, and the average fall per mile is 15.37 feet.

This fall is well distributed, there being very little concentration of fall above this point.

Just below Barnard station there a small shoal with good building room and a site for a dam, but the fall is not very great.

A mile and a half above Barnard, and a mile above the mouths of Papaw and Walnut creeks, there is a shoal which has only a small fall, but the river is narrow, affording a good site for a dam but little room for buildings. The river is very rapid for half a mile below this shoal.

There are small rapids above Alexander station and again about 3 miles above this station, but there are no very favorable sites for dams and not much space for buildings.

Above Asheville the character of the river again changes, and from a very rapid mountain stream it comes to remind the observer of the streams of the eastern part of the state. The bed of the river is overlaid with a stratum of coarse sand and gravel, and in general is quite smooth, though the current is interrupted at intervals by ledges and boulders. The fall is very much more gradual and evenly distributed than is usual with mountain streams. The distance from Asheville to Brevard by river is 48.35 miles, and the total fall only 130.9 feet, the average fall per mile in this distance being 2.7 feet.

There are only two shoals on this part of the river of more than a few inches fall. Eight and one-half miles above Asheville is the SANDY BOTTOM SHOAL, the largest in this part of the river. The total fall is 22.6 feet in about 18,000 feet.[1]

About 12 miles above Asheville, and 3½ miles above the Sandy Bottom shoal, is LONG SHOAL, where, in 12,920 feet, the fall is 18.3 feet.

TRIBUTARIES OF THE FRENCH BROAD RIVER.

The French Broad has a number of tributary streams upon which have been already or can be developed small waterpowers by the construction of dams across the narrow, rocky gorges through which these streams make their way to the river. The more important of these are as follows:

Spring creek, which rises on the eastern slope of the Newfound mountains in the extreme southwestern portion of Madison county, flows in a northerly direction and joins the French Broad river at Hot Springs, above which point it has a total drainage area of 66 square miles.

Laurel river, which rises in the Bald mountains in the extreme northeastern corner of Madison county, flows in a southwesterly course and joins the French Broad about 1½ miles above Hot Springs, having a drainage area of 141 square miles.

Ivy river, the next of the important tributaries in the ascending order, rises on the western slopes of the Craggy mountains near Yates Knob and, flowing in a general westerly course, joins the French Broad river a little more than 2½ miles above Marshall, having a total drainage area of 176 square miles. On this stream there are several shoals, which, though not of great importance, are yet deserving of mention in this connection.

One mile above the mouth of the stream there is a natural fall of 6 feet in a distance of 200 feet, and there is an excellent location for a dam on solid rock where most of the fall is concentrated. The width of the stream here is 60 to 70 feet. The adjacent ground is not very satisfactory for large building sites, but the power can be easily transmitted electrically to the town of Marshall only a few miles distant.

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[1] The information concerning the shoals between Asheville and Brevard was obtained from the Annual Report, Chief of Engineers, 1876, p. 722.

On Big Ivy, just above the mouth of Little Ivy, there is a grist- and saw-mill, located on a good site, with a dam about 8 feet high, giving a fall of 10 feet. Below this the stream is rapid and descends rapidly, so that this fall could doubtless be increased.

At Democrat post-office, one mile above the Burnsville road, there is a grist-mill, located on a good site, with a 10-foot log dam. This power might be considerably improved by adding the 2 feet fall just below the dam and in other ways. There is a suitable place for building just at or near the dam.

On the Middle fork of Little Ivy river, just at its junction with Paint fork, there is a mill with an overshot wheel using about 15 feet fall.

Sandy Mush creek, which is joined by the Turkey creek, both having their rise in the slopes of Newfound mountains in the western part of Buncombe county, flows in a northeasterly course and joins the French Broad at the west side of the river at a point about 4½ miles above Marshall. It has a total drainage area of 86 square miles.

The *Swannanoa river*, which rises against the southern end of the Black mountains between the Craggies and the Blue Ridge and flows thence in a general southwesterly course, joins the French Broad about a mile above Asheville, having a total drainage area of 132 square miles. The only power on this stream worthy of mention is that a few miles above the mouth, which is now being utilized by the Asheville city authorities to pump the water supply up to the city reservoir.

Hominy creek rises near the southern end of Newfound Mountain ridge, a few miles east of Canton, in Haywood county, and flowing eastward joins the French Broad about 2 miles above the mouth of the Swannanoa, having a total drainage area of 93 square miles. On its course there are several shoals and 2 or 3 small mills, but none of great importance. A short distance above its mouth its largest power has been improved and is used for developing electricity by one of the Asheville street railway companies. There is here a total fall of 30 feet, and it is reported that 300 horsepower is used during the larger portion of the year.

Cane creek, the next above, rises on the western slope of the Blue Ridge just south of Swannanoa Gap, and, flowing in a northwesterly course, joins the French Broad river on the east between Henderson and Buncombe counties. It has a total drainage area of 90 square miles.

Muddy creek, which enters the French Broad a few miles above the last-mentioned, rises in the Blue Ridge some miles to the southwest of Hendersonville and flows first in a northerly and then a northwesterly direction, having a total drainage area of 113 square miles.

Mills river, which enters the French Broad on the west, nearly half a mile above the mouth of Muddy creek, rises on the southern slopes of the Pisgah mountains and flows in a general easterly course, having a total drainage area of 74 square miles.

PIGEON RIVER.

Pigeon river rises in the extreme southern portion of Haywood county and against the northern and eastern slopes of the southern end of the Balsam mountains near their junction with Tennessee ridge; it flows thence in a northerly course for a distance of some 20 miles, when it crosses the Murphy division of the Western North Carolina railroad at Canton. Thence it flows westerly for a distance of about 10 miles, and then northwesterly about 25 miles to the Tennessee border, where it breaks across the Great Smoky mountains in a deep, rocky and inaccessible gorge. From this point it flows on in a northwesterly course for a distance of some 25 miles more, where it joins the French Broad, and its water ultimately reaches the Gulf through the Tennessee and the Mississippi.

Where this river is crossed by the Western North Carolina railroad at Canton it is to be seen as a rather quiet, placid stream, and it maintains this character to a greater or less degree for a distance of 10 to 15 miles below this point. Lower down, however, and on to where it crosses the state line into Tennessee, it becomes a rapid, rushing stream, flowing in a deep, narrow, rock-bound gorge. The total distance from Canton to the Tennessee line, following the windings of the river, is not much short of 50 miles, and in this distance its aggregate fall is approximately 1300 feet, or 26 feet to the mile.

Just above its junction with Richland creek it has a drainage basin of 268 square miles. It has a total drainage area above the Tennessee line of 572 square miles. Of this total area in 1880, 40,000 acres were reported as being in cultivation, 11,000 acres in grass, and 315,000 acres, or about 86 per cent. of the total area, were still forest-covered. The total rainfall of the basin for the year as determined by a single station at Waynesville, observations at which extend over between 3 and 4 years, is given by the United States Weather Bureau as 48.4 inches, distributed as follows: spring, 13.7; summer, 16.6; autumn, 7.5; winter, 10.6 inches.

WATERPOWER ON PIGEON RIVER.

But few waterpowers on this stream have been developed, and there are but few shoals about which much is known. From the Tennessee line, up the stream for 20 or 25 miles following its windings, the river gorge is deep, narrow and irregular. The country is exceedingly rugged and inaccessible, and the stream is almost a continuous rapid. At a number of points the conditions are favorable for the construction of dams, which would yield a fall of water varying with the height of the dam, and while at most of these points there is no space available for extensive buildings, the power could be easily transmitted to Waynesville by electricity and there used in manufacturing enterprises. Further up the river the first shoal to be met with is one located about three-quarters of a mile below the mouth of Crabtree creek, where there is a fall of about 3½ feet in a distance of 400 feet, but as there is here no place suitable for the construction of a dam, the power is not a promising one for development.

About 3 miles below Clyde there is another small shoal now occupied by a small grist-mill. The development here consists of an ordinary log dam 4 feet in height, built across the top of the shoal. The mill is operated by an undershot wheel, which uses only a small portion of the water available.

About one-half mile below Clyde there is still another small shoal, partially developed for the operation of a saw- and grist-mill. There is here a log dam 8 feet high, and, as in the last-mentioned case, this mill uses only about half of the water at the period of the lowest flow.

At a point 1½ miles above Canton there is said to be a fall of several feet in a short distance, where the conditions are quite favorable for the construction of a dam, which would increase this fall considerably. Still further up the river there are a number of shoals where small waterpowers may be developed for the operation of small grist- and saw-mills.

On the three principal tributaries lying on the west side of the river —Cataluche, Jonathan and Richland creeks—there are also a number of small shoals capable of being developed to powers either for local use or for transmission, electrically, to Waynesville.

CHAPTER XIII.

THE TENNESSEE AND HIWASSEE RIVERS.[1]

THE TENNESSEE RIVER AND TRIBUTARIES.

The Tennessee river is the largest of the North Carolina streams west of the Blue Ridge, being slightly larger than the French Broad. It rises on the north slope of the Blue Ridge in Rabun county, Georgia, and flows in a general northerly course across Macon and a portion of Swain county to a point about 10 miles east of Bryson City, where it is joined by the Tuckaseegee river and flows in a general westerly course, forming the line between Swain and Graham counties, and, like the mountain streams already described, crosses the Great Smoky mountains in a deep, narrow, rocky gorge. From this point the river flows in a northwesterly course for a distance of 40 to 50 miles, to where it joins the Holston, and thence flows to and through the Mississippi to the Gulf. The total drainage area of the river basin above the Tennessee line is 1831 square miles, of which, according to the United States Census Report in 1880, there were 83,000 acres of land in cultivation, 11,000 acres in grass, and 1,078,000 acres, or 90 per cent. of the whole, in forests. The total rainfall of the year in this region is given by the United States Weather Bureau as 62.2 inches, distributed as follows: spring, 14.6; summer, 17.5; autumn, 12.7; winter, 17.4 inches. In most of these mountainous counties autumn is the driest season. The soil of this region is deep and fertile, being well adapted to the grasses, cereals and tobacco. It contains a larger portion of clay than is found in some of the more northeastern mountain counties, but still may be fairly considered as a loam. The basin contains numerous valuable mineral deposits, notably the mica and corundum deposits in Jackson and Macon counties.

Throughout the larger portion of its course from the Georgia line to Franklin, the river is, for this region, a rather sluggish stream with occasional shoals, but from five miles below Franklin to beyond the Tennessee line, it runs through a deep gorge with rock bottom and sides, and for this entire distance is practically a succession of shoals. A few important waterpowers have already been developed, but there are a number of places where the conditions are favorable for the development of much larger powers, as shown by the following notes.

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[1] By E. W. Myers and J. V. Lewis.

For 15 miles below Rocky Point ferry the river plunges through a deep gorge formed by the spur of the Bald mountain on the north and the Unicoi mountains on the south, the stream varying in width from 30 to 150 yards, and the fall from 10 to 40 feet per mile. From Rocky Point ferry up to the mouth of the Tuckaseegee river, a distance of about 23 miles, the mountains dwindle gradually, the river becomes broader and the fall diminishes to an average of about 15 feet per mile.

The character of the river bed for the larger part of its course in North Carolina is practically uniform. It is crossed by bodies of gneissic, schistose and slaty rock, in some places flat and in other places inclined at steep angles. The variations in the rock are not great enough nor abrupt enough to produce vertical falls of great height, but sufficient to produce here and there numerous small rapids and plunges of from 6 inches to 2 feet each, giving an aggregate fall of from 10 to 40 feet per mile.

TABLE OF DECLIVITY IN NORTH CAROLINA.[1]

Locality.	Distance.	Altitude.	Fall per mile.
State line	0.0	1224	
Rocky Point	5.0	1306	16.5
Calhouns	19.0	1512	15.0
Alarka creek	35.0	1745	14.0
Franklin ford	59.5	2055	13.0
State line (Georgia and North Carolina)	80.0	2240	9.66

Average fall per mile in North Carolina 13.5 feet.

For measurements of the flow of the Little Tennessee river at Judson, 4 miles above its junction with the Tuckaseegee, see pp. 329 to 331.

WATERPOWER ON THE TENNESSEE RIVER.

The first 4 miles of the river up from the Tennessee line lies in a deep, rocky gorge, through which it passes as a succession of rapids. The volume of water and the fall are ample for large possibilities in waterpower development, but the rocky walls of the stream are so steep and high, the gorge so narrow, and the region so rugged as to be quite inaccessible. The first accessible shoal of importance is half a mile above Rocky Point ferry and just below the mouth of Twenty-mile creek; it has a fall of about 5½ feet in a distance of 200 yards. The river here is quite narrow, not being more than 40 feet wide in portions of the shoal. At the head of the shoal it is considerably wider, though there are good abutments and foundation for a dam. There is also an abundance of space for buildings.

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[1] See Annual Report, Chief of Engineers, 1876, p. 716.

Three-fourths of a mile above Twenty-mile creek there is a rapid with a fall of about 4 feet in 100 feet. Here the rocky banks of the river are so steep and high that a dam 100 feet high would not be over 300 feet long at the top. Stone for the construction of such a dam and for other purposes is abundant in the vicinity, but there is no space for buildings. There are the possibilities here for a waterpower of considerable magnitude.

About a mile above this last, and just below Fairfax post-office, there is a rapid with a fall of about 5 feet, distributed somewhat uniformly through a distance of 250 yards. The river is quite wide here, however, and the country is exceedingly rough. A dam could be built almost anywhere on the shoal, but there is no suitable building space for a mill.

Half a mile above this shoal, and again one mile above it, there are rapids of small fall, extending over considerable distances, and not, therefore, of much importance.

About 2 miles above Fairfax there is a better rapid, having more fall than the last-mentioned and a little space for buildings, but the channel is quite broad, and the locality is not regarded of much importance as a waterpower possibility.

During the next 7 miles up the river there are no shoals with any important concentrated natural fall, though there are a number of places where dams might be built and powers developed, the current being sufficiently rapid to prevent the accumulation of water below the dams in time of freshets.

About a quarter of a mile above the mouth of Hazel creek there is a rapid having a natural fall of about four feet in two hundred yards, and consisting of two equal parts separated by about a hundred yards of smooth water. Neither place is suitable for building a dam, as the banks are not good, the south bank in particular being bad, and besides the river here is quite wide.

From this point to about one and a quarter miles above Wayside post-office, a distance of about one and three-quarter miles, the river is very placid, running smoothly and containing no rapids to speak of. One and a fourth miles above Wayside there is a small rapid having a fall of about 18 inches in 200 to 250 feet. The river is broad, however, and neither bank is good, nor is there much level room for building,

so that the shoal is practically of no importance. There are two rapids between this place and Bushnell, but they are small and of little interest.

From the mouth of the Tuckaseegee river, at Bushnell to the mouth of the Nantahala river, a distance of about 7 miles, the stream is very rapid and there are available places for dams, but there are no shoals of any consequence, and the railroad follows the river so closely that it would be impracticable to utilize fully any power that might lie in this section of it. For the five miles above the junction with the Nantahala the stream was not examined, but it is said to be of about the same general character as the five miles below this point.

Five miles above the mouth of the Nantahala we found a small shoal having a fall of about two feet in one hundred. There is good foundation for a dam and rock abutments on the banks, but the space for buildings is small.

From this point to the mouth of Brush creek, a distance of something over four miles, the river is quite rapid and shoaly, but there are no large concentrated natural falls.

At the mouth of Brush creek the river divides and includes an island about a quarter of a mile long. On the east side of the island there is a shoal having ample fall for fair power development, but the location is not favorable for a permanent dam. On the west side, and at the foot of the island, there is now a small saw- and grist-mill, using a head of about six feet, produced by a log dam of the same height built at the foot of the shoal. Also, just above the mouth of Brush creek, there is a small shoal, but of no particular importance.

Two miles and a half above the mouth of Brush creek, and about fourteen miles from Franklin, there is a shoal having a natural fall of about two feet with a good site for a dam and an ample space for buildings.

Then, for the distance of about one mile, the river is comparatively placid and sluggish. Above this for about a mile or a mile and a half, there is a rapid consisting of a series of small cascades 100 to 150 yards apart, none of them having separately a fall of more than a foot.

For a distance of about three miles there is very little fall in the river, and the only shoal is a mile below the mouth of Cowee creek and ten miles from Franklin. This shoal has a fall of about one foot over a solid rock ledge extending entirely across the river and giving good foundation for dam and a good abutment on the north side, but on the south side the conditions are not so favorable. There is, however, ample space for buildings.

About a quarter of a mile below the mouth of Watauga creek there

is a small shoal with a fall of about one foot, but the rock in the bed of the stream is not favorable for the foundations and abutments of a dam.

Just above the mouth of Iola creek, and about 5 miles from Franklin, there is a small shoal with a little fall consisting of rock ledges across the river, and there is plenty of good building room, but the banks are not favorable for a dam.

Above this point the river is comparatively of gentle grade, and there are no available waterpowers.

A discharge measurement at Franklin, September 13, 1895, gave 426.9 cubic feet per second, equivalent to 48.5 horsepower per foot fall. The measurement was made at low water.

TRIBUTARIES OF THE TENNESSEE RIVER.

The Tennessee has numerous tributary streams in North Carolina, one of which, the Tuckaseegee, has a drainage basin above the junction of the two slightly larger than that of the Tennessee. The more important of these tributaries are the Cheowah, the Tuckaseegee, the Nantahala, and numerous smaller streams. These more important tributaries, together with their possible waterpower development, may be briefly described as follows:

THE CHEOWAH RIVER.

The Cheowah river rises on the western slopes of the Long Ridge mountains in the neighborhood of Red Marble gap in the extreme southwestern corner of Graham county. Thence it flows in a general northwesterly and northerly course, joining the Tennessee river 2 or 3 miles above the state line. Its drainage basin embraces 219 square miles, lying between the Cheowah mountains on the north, Long Ridge on the south, and the Unicoi mountains on the west, and is fed by numerous small mountain streams. Owing to the fact that more than 80 per cent. of the region is still forest-covered and the soil is deep and porous, the water in this region has a fairly uniform flow.

The total fall in the river from the forks to the mouth is about 780 feet, the distance in a straight line about 9 miles, following the course of the river about 14 miles, and the average fall per mile between 55 and 60 feet.

For about 6 miles up from its mouth this river has not been carefully examined. It runs through a deep, rugged gorge, and is a succession of shoals and rapids for the lower 7 or 7½ miles of its course. The first place at which the river was observed was about 6 miles from its mouth and about one mile below the mouth of Cochran creek. The river was one continuous rapid, with a fall of not less than 50 feet in

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The total fall in the river from the forks to the mouth is about 780 feet, the distance in a straight line about 9 miles, following the course of the river about 14 miles, and the average fall per mile between 55 and 60 feet.

For about 6 miles up from its mouth this river has not been carefully examined. It runs through a deep, rugged gorge, and is a succession of shoals and rapids for the lower 7 or 7½ miles of its course. The first place at which the river was observed was about 6 miles from its mouth and about one mile below the mouth of Cochran creek. The river was one continuous rapid, with a fall of not less than 50 feet in

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a short distance, the water being very swift. The stream could be dammed anywhere and large power secured, the amount of fall being in proportion to the height of dam or the length of race. Owing to the depth and narrowness of the gorge there is but little space for any buildings other than power-houses, and the power would need to be transmitted electrically to points on the railroad where manufacturing plants can be located. There is an especially good place for a dam at the mouth of Cochran creek, as the river is there quite narrow.

For about half a mile above this point the river is quite rapid, but contains no shoals of any special importance, the only one worthy of notice being nearly a half mile above the entrance of the creek, and this one has only about 2 feet fall, but it has a good site for a dam, by which the fall could be decidedly increased.

Between this point and the mouth of Santeetla creek, a distance of about 3 miles, there are 2 small shoals, the lower midway, with a natural fall of 4 feet in a distance of 150 feet, and the upper shoal, half a mile below Santeetla creek, where there is a fall of about 3 feet in 100 feet. In both cases the rocky bed of the stream and rocky walls of the gorge afford conditions favorable for building dams which would greatly increase the fall, the stone near-by being abundant and suitable for the purpose. At both shoals there is also ample space for the location of buildings.

Near and above the mouth of Santeetla creek there is, in the Cheowah, a series of little cascades, each from 6 inches to one foot in height, the water flowing over a floor of solid rock all the way for a distance of a mile or more. Three-quarters of a mile below the mouth of East Buffalo creek there is a shoal having a fall of 3 feet in a short distance over a solid rock ledge. At this point there is ample space for necessary buildings and an abundance of stone suitable for dams and building purposes.

Half a mile above this there is a shoal having a fall of 2 feet in 50 over solid rock ledges extending across the river, and offering good foundations and abutments for a dam; and there is ample space for buildings in the vicinity.

About three-quarters of a mile above the last-mentioned point, and half a mile above the mouth of East Buffalo creek, there is a small rapid having about 2 feet fall in 100 yards, most of the fall being in 2 small plunges, one at the head and the other at the foot of the shoal. Solid rock ledges extend completely across the stream, and the banks are steep and rocky, furnishing a good site for a dam; and the supply of stone suitable for the construction of dams and buildings is ample and near at hand.

THE TUCKASEEGEE RIVER.

The Tuckaseegee river rises on the northern slopes of the Blue Ridge and the Tennessee Ridge mountains in the southern part of Jackson county, and flows in a general northwesterly course, thence across this county and the southern part of Swain county to its junction with the Little Tennessee. It has a drainage area of 833 square miles. Above the mouth of the Occoneeluftee its drainage area, which lies almost wholly in Jackson county, embraces an area of 418 square miles.

Like other mountain streams, the Tuckaseegee, for the larger portion of its course, flows rapidly through a narrow, rocky channel, and along its course there are numerous places where, by the construction of dams, excellent waterpowers can be developed.

For measurements of the flow of the river at Bryson City see pp. 326-328.

Proceeding up the river, the shoals will be named in the order of occurrence:

About one and one-fourth miles above Bushnell, where the Tuckaseegee joins the Little Tennessee, there is a shoal having a fall of about 7 feet in 200 yards. A dam could easily be built here, although the river is wide, but there is no level ground suitable for the erection of buildings. There is a somewhat similar shoal about 200 yards above this place having a fall of about 2 feet, the two shoals in reality constituting the same shoal.

About one mile above the last-mentioned site, and just below the mouth of Forneys creek, there is a small shoal having only a few inches fall and is of no importance.

One-fourth of a mile above Forneys creek there is a short shoal having a fall of about 18 inches or 2 feet in about 50 feet, caused by ledges of rock extending straight across the river. There is here no place where a dam could be built on account of the railroad which is here very close to the river. There is ample building room in the bottom on the west side of the river about 20 yards from the top of the shoal.

A quarter of a mile above this shoal there is another, having a fall of about 5 feet in 200 feet, but though the channel is quite narrow, any dam which might be built would have to be quite long, the river banks being flat and rocky and extending back some distance from the river. The river fills the whole space in time of high water. Immediately above this shoal there are a number of small rapids of a few inches fall each, but there is no concentration of fall in noteworthy amount until within half a mile below Bryson City.

Here there is a shoal having, in a distance of about 150 yards, a fall estimated by the eye as certainly not less than 5 feet. The site is of little importance, as there are broad bottoms on each side of the river lying only a few feet above the level of ordinary high water, and a large proportion of them is subject to overflow in time of freshet.

Between Bushnell and Bryson City the river is uniformly very swift, and although there is no concentrated fall the fall is large, being certainly not less than 15 feet to the mile and in all probability more than that amount.

About 200 yards above Bryson City there is a shoal very similar to the one below the place, the fall being 3 or 4 feet, estimated as before. The conditions for development at this shoal are somewhat more favorable, the south bank being very steep and rocky and the north bank much higher. The site is not regarded as of any special importance.

Throughout this part of its course the river is between 200 and 300 feet wide.

From this point, up to within three miles of Dillsboro, there are no shoals, and the river is skirted by strips of bottom-land.

Three miles below Dillsboro there is a small, short shoal having a fall of about 2 feet. The river is wide, but there is plenty of room for buildings.

About half a mile above this place, and just below the mouth of Dicks creek, is the beginning of a series of rapids that extend for half a mile up the river. There is a large fall in the rapids, the river is narrow and down in a deep gorge.

Just below the town of Dillsboro there is an abandoned waterpower which was used until a few years ago to operate a large saw-mill. The dam, part of which is still standing, was built of triangular wooden frames bolted to the bed of the river and planked over on the up-stream side, and extended in a broken line across the river. At each of the angles, timber cribs, filled with stone, were placed to add strength to the dam, which was about 8 feet high. There was no race, the water being turned directly to the wheels. The construction of the Murphy branch of the Southern Railway cut through the north end of this dam and the mill and power have since been abandoned.

A discharge measurement of this river, made September 9, 1895, at the railroad bridge just below Dillsboro, gave a discharge of 398.5 cubic feet per second at low water, equivalent to 44.2 horsepower per foot fall.

Between Dillsboro and the forks of the Tuckaseegee, a distance of 10 miles in an air-line and about 17 miles following the course of the river, the average fall is at the rate of 10 feet per mile. The course of the river is tortuous and the bottom-lands bordering the river are frequently quite broad. The fall is well distributed, there being no shoals of importance in this distance.

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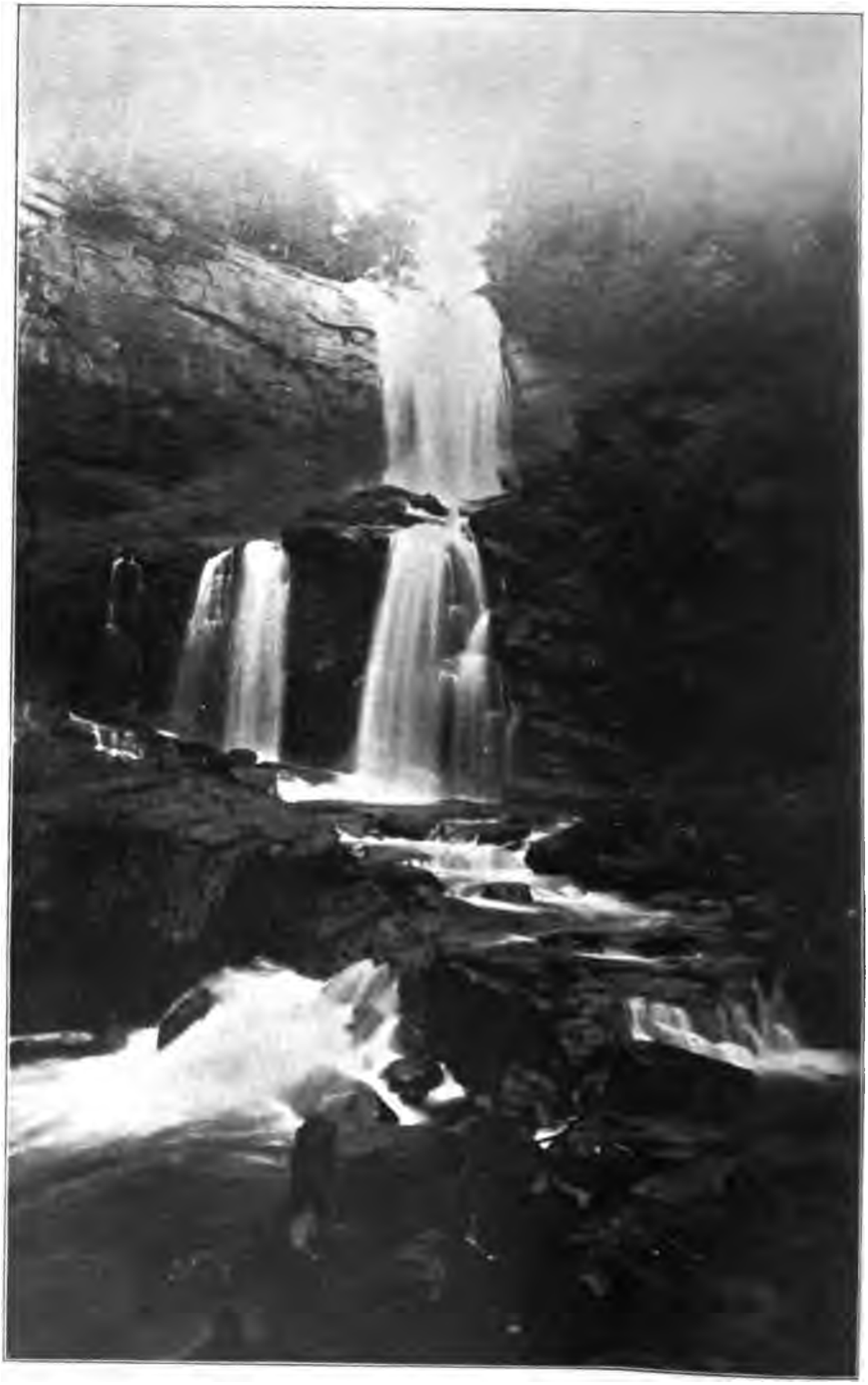

TUCKASEEGEE FALLS, JACKSON COUNTY

Above the forks the character of the stream changes; the fall is greatly increased and there are numerous places where large fall can be obtained and powers of corresponding magnitude developed in consequence. The most noted of these possible power sites is that known as THE FALLS OF THE TUCKASEEGEE, situated on the smaller or west fork, about five miles above the junction with the east fork. The fall here in a distance of less than one mile is about 400 feet, and is over 500 feet in less than two miles. The drainage area above this place is nearly 40 square miles, and it is about 12 miles on an air-line to the nearest railroad station, the distance to Dillsboro and Sylva being about the same (Plate XIII).

On this stream, as on the French Broad river below Asheville, the main obstacle in the utilization of the powers between Bushnell and Dillsboro is the position occupied by the railroad track which skirts the river bank for the entire distance, and any but a very low dam would seriously interfere with the road-bed, even in time of low water, and would cover it altogether in time of flood.

Below Bushnell the country is extremely rough and mountainous and very thinly settled, and the present roads are entirely impracticable for any traffic.

The principal tributaries of the Tuckaseegee river in their order ascending the stream are *Forneys creek*, *Nolans creek*, *Deep creek*, the *Occoneeluftee river*, *Scotts creek* and *Caney fork*, all entering from the north.

Forneys creek, Nolans creek and Deep creek are all small streams, rising far up on the mountain slopes, having a large fall and affording some very good small powers, at present used for running small saw- and grist-mills.

The *Occoneeluftee river*, the largest tributary, rises in the Great Smoky mountains in the extreme northeastern part of Swain county, and flowing in a southerly and then in a southwesterly course, joins the Tuckaseegee about four miles east of Bryson City, draining an area of 198 square miles. The current is uniformly rapid and the fall appears to be large but is very uniformly distributed, there being no shoals on the river as far as it was seen, of any considerable value for power purposes, though doubtless there are numbers of places where power may be secured by damming.

Only two were seen between the mouth and Yellow Hill, each having a fall of about two feet in about 200 feet. In both places the river is wide and the channel much obstructed. Above Yellow Hill the river becomes still more rapid and there are, it is said, a number of places where small powers can be developed.

Scotts creek, the next important tributary of the Tuckaseegee, has its head springs on the west slopes of the Balsam mountains near Balsam Gap, and, after flowing for about 12 miles, measured in a straight line, it empties into the Tuckaseegee just below the town of Dillsboro, draining an area of 65 square miles.

The first power on this stream is in the town of Dillsboro, where is located a small saw-mill and locust-pin factory, using a small amount of power, obtained by a dam across this creek.

About 2 miles above Dillsboro, and in the town of Sylva, there is a small power, developed some time ago for the purpose of running a corundum-mill. The fall used, about 5 feet, was all obtained from the dam. The power here is, of course, very limited in quantity, only suitable for operating a small plant. There are no other developed powers on this creek.

NANTAHALA RIVER.

The Nantahala river, which joins the Tennessee about 5 miles (by a straight line) above the mouth of the Tuckaseegee, rises on the northern slopes of the Blue Ridge in Rabun county, Georgia, and flows in a general northerly direction throughout its entire course. It has a total drainage area of 184 square miles, as compared with the Tennessee river, which rises near the same general region, and which has above the mouth of the Nantahala a drainage area of 467 square miles. This shows that the Nantahala throughout its entire course runs in a narrow, deep basin and has but few tributary streams. For the lower third of its course it runs in a narrow gorge from one to two thousand feet deep, having in this part of its course, which parallels the Murphy division of the Western North Carolina railroad, practically no tributaries.

Waterpowers have been developed on the Nantahala at two points:

(1) At Ricard and Hewitt's talc-mill, about 10 miles (straight line) above the mouth of the river, where a small dam and a race furnish power sufficient for operating this mill.

(2) At Hubbard and Mertz's saw-mill, about 3 miles further up the stream, where the river has cut through the Nantahala mountains, where it first reaches the railroad. The drainage basin of the river above this point has a total area of 152 square miles, practically all of which is forest-covered. At this latter point it is said that quite a large power could be developed, as the river flows here through a deep, narrow, rocky gorge into a wider channel below.

From this last-mentioned place down to the mouth of the river there are numerous undeveloped shoals with suitable places for the construction of dams, the stream-bed being narrow and its bottom and sides being of rock. The fact that the railroad track is but a few feet above

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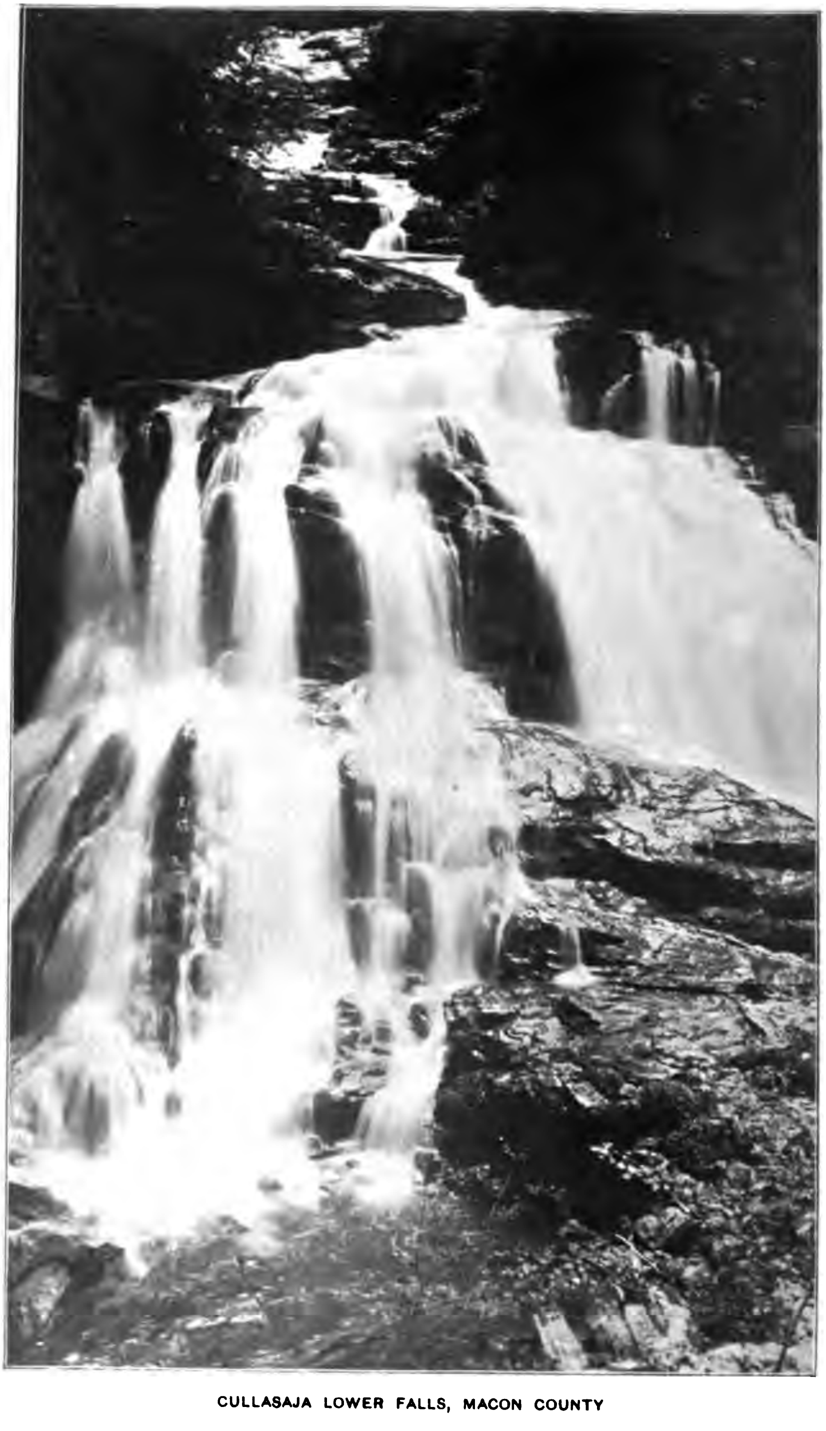

CULLASAJA LOWER FALLS, MACON COUNTY

the bed of the stream would interfere with the large development of any of these shoals.

CULLASAJA CREEK.

There are numerous other small tributaries of the Little Tennessee on which either have been or can be developed important though small waterpowers. Thus, on the Cullasaja, one of these smaller tributaries of the Little Tennessee, at Corundum Hill the power is developed by a 7-foot dam, giving a fall of 9 feet at the mill, this water turning a 40 horsepower turbine-wheel. At the CULLASAJA FALLS, 7 miles above Franklin, there is said to be a vertical fall of 95 feet and a total fall of 310 feet in one-fourth of a mile.[1] This is known as "Cullasaja lower falls." About 6 miles above this there is a succession of rapids and falls, in a narrow gorge, which together, are known as the "Cullasaja upper falls." An excellent power could be developed here also (Plate XIV).

HIWASSEE RIVER AND TRIBUTARIES.

The Hiwassee river rises on the northern slopes of the Blue Ridge in Towns county, Georgia, and flows in a general northerly-northwesterly course by way of Hayesville, Clay county, North Carolina, and then in a general west-northwesterly course across Clay and Cherokee counties into Tennessee, where it joins the Tennessee, and through it flows into the Mississippi.

The two most important of its tributary streams are the Nottely, which rises on the north slopes of the Blue Ridge mountains not far from the source of the Hiwassee in Union county, Georgia, and flows in a general northwesterly and northerly course, joining the Hiwassee some 5 miles below Murphy; and the Valley river, which rises in the extreme northwestern corner of Cherokee county, near Red Marble Gap, and flows in a southwesterly course, joining the Hiwassee at Murphy. The Nottely river has a drainage area of 305 square miles, and the Valley river, 128 square miles.

The drainage basin of the Hiwassee above the Tennessee line is 1084 square miles. Of this area, according to the census of 1880, there were 40,000 acres of land in cultivation, 35,000 in grass, and 619,000, or 89 per cent. of the whole, were still forest-covered, and in portions of the Valley river basin there are numerous valuable deposits of marble, talc and iron ore, and also some gold, silver and lead. Along portions of Nottely and Hiwassee rivers also there are some fine farming lands and valuable deposits of marble and talc.

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[1] The fall here was measured by Dr. H. S. Lucas, with an engineer's level.

For measurements of the flow of the Hiwassee river at Murphy see pp. 331-334.

WATERPOWER ON HIWASSSEE RIVER.

In connection with the following notes concerning possible waterpower developments on the Hiwassee river, it must be said that the part of the river at and for 13 miles above the Tennessee state line has not yet been carefully examined owing to its inaccessibility. But according to the best information obtainable, there are in this portion of the river no shoals which could be developed into large powers; and, indeed, it is reported that there are no shoals in this part of the river with a fall greater than a few inches.

Below Murphy the river is a rapid stream, but the fall is well distributed, there being no places where there is any considerable amount of concentrated fall. The distance from Murphy to the North Carolina-Tennessee state line, following the course of the river, is about 28 miles, and the total fall in the stream is about 300 feet, or between 10 and 11 feet to the mile.

Between Murphy and Hayesville, a distance of about 19 miles following the course of the river, the total fall is about 250 feet and the average fall per mile about 13 feet.

The first shoal seen was about a mile above Ogreta post-office and about 15 miles above the state line. This shoal had a fall of about 3 feet in 200, and at its crest there is an excellent foundation for a dam and an abundance of rock on the spot for building purposes, but the river at this point is about 300 feet wide. There is ample space for buildings on the northeast bank.

From this point on up to within a half mile of Murphy there are occasional rapids in the river but no important shoals, and though places where dams could be built are numerous, no fall could be secured beyond what the dam would give, and the river is from 250 to 300 feet wide.

Half a mile below Murphy is a site that is said to be probably the best in the county. There is no natural fall in the river at this place, but the stream is rapid and wide enough to allow of the easy escape of water below the dam, and there is here a good foundation for a dam and good abutments on both banks. On the southwest bank of the river there is a precipitous bluff of solid rock 100 feet or more in height, and this recedes from the river almost at right angles. Below this bluff can be found ample space for buildings, which would here be in a measure protected from the effects of flood. A dam at this place would need to be quite long, but an ample supply of rock can be obtained close at hand for its construction. The drainage of the river above this point is 570 square miles and the rainfall 61 inches per annum. This power might be developed, conveyed electrically to the town of Murphy, and used there for operating a variety of manufacturing establishments. In the same manner the shoals mentioned on the river in the succeeding paragraphs might be developed and the power from each be brought to Murphy and there used for lighting and manufacturing purposes.

About 5½ miles above Murphy there is a shoal having a fall of about 2 feet in 100. The river is quite narrow and could easily be dammed, as there are good foundations and abutments for a dam, and plenty of stone on the spot for building purposes. The locality is not favorable for buildings, but the power could easily be transmitted to Murphy as suggested above.

Eight and one-fourth miles above Murphy the Cherokee Lumber Company has in part utilized the finest power on the upper part of the river, though not for power purposes.

There is a fall of about 3 feet in the river at this point over a solid rock ledge, and across the top of this a dam has been built for the purpose of floating logs to the steam saw-mill which they have at this point. This place could be well used for power purposes, as the foundations and abutments for a dam are good and there is ample space for a power-house and the other necessary buildings.

About 10 miles from Murphy, just above the Shallow ford, there is a small shoal having a fall of about one foot in 50. Here again the river is narrow and the channel restricted, and a good dam could easily be built, thus greatly increasing the fall available, and there is plenty of good level building room.

The Hiwassee is a very rapid stream, flowing in a channel which it has cut out of the solid rock, and in many places the banks are quite steep and precipitous and rocky, thus affording good sites for dams. It, like the other mountain streams, is subject to violent floods, frequently rising to a height of 10 feet above its normal level in a very short time, and dams would need to be strongly built to withstand these floods.

From Murphy to Hayesville the stream has not been very closely examined, but it possesses the same general characteristics as noted above for the river in general, only its channel is more rocky and more restricted, and the banks higher and steeper.

Nothing is known as to the waterpower of the Nottely river, as it was not examined and inquiry failed to bring to light anything of interest concerning the stream. There is no power worthy of mention in this connection on Valley river.

PART IV

DISCHARGE MEASUREMENTS ON THE NORTH CAROLINA RIVERS

E. W. Myers

DISCHARGE MEASUREMENTS ON THE NORTH CAROLINA RIVERS.

CHAPTER XIV.

STREAM MEASUREMENTS.[1]

The power that can be developed at any point on a stream is dependent solely on the available fall and on the available quantity of water.

The fall can be easily and accurately measured once for all with an engineer's level, but the determination of the quantity of water flowing is by no means such a simple matter, for this is varying constantly, from hour to hour and from day to day, so that an accurate gauging of the flow made on one day will not of itself serve to determine the volume of the water on some other day when the stage of the river is different.

To the engineer who has to plan a hydraulic construction, and to the investor who desires to purchase waterpower, an accurate knowledge of the flow of the stream where the power is located is a matter of the first importance. It is necessary to know the minimum flow, that the construction may be so planned as to give the desired power, and the maximum flow that the structure may be proportioned to withstand the enormous forces that may be brought to bear on it in time of flood. With all its importance, information of this character has been available for but a few streams, and these mainly located in the New England states, where the peculiarities of climate and topography are such as to render the data thus gained of little use in estimating the probable flow from other areas, lying under widely different conditions such as prevail in the South Atlantic states.

It is evident that an accurate investigation of the flow of a stream under all conditions cannot be carried out in one year or in a few years, and so in almost every case where the volume of water carried by a stream was desired it has been necessary to rely on computations based on the rainfall over the drainage basin, supplemented by perhaps a single gauging of the stream, and from this an effort is made to determine the minimum and average dry-season flows. It is scarcely necessary to say that such estimates are open to very serious error, the correctness of the figures for the flow thus determined being entirely dependent on the training and judgment of the engineer and his knowledge of the conditions prevailing over the drainage basin. Even with the most accurate knowledge of the topography of the basin the flow is a result which is dependent on so many varying factors such as the amount and distribution of the rainfall in different years or periods, the temperature of earth and air, the wind movements, and the conditions of saturation of the soil and sub-soil, which, so far as known, follow no definite laws and cannot be predicted, that estimates of flow based on such calculations must be very unsatisfactory and are frequently the source of much inconvenience and sometimes of serious money loss.

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[1] By E. W. Myers.

Owing to the recent developments in the electrical transmission of power and the growing tendency to bring the cotton-mill to the cotton instead of carrying the cotton to the mill, together with the growth of other manufacturing interests, waterpowers which have heretofore been of little commercial value have become valuable, for, generally speaking, waterpower is much cheaper than steam-power. Thus the numerous waterpowers of the South Atlantic states have come into prominence and information concerning them has been eagerly sought.

Realizing the need of more accurate knowledge of this very valuable source of wealth, in the autumn of 1895 the Geological Survey, in co-operation with the U. S. Geological Survey, began the investigation of the flow of streams as recorded in the following pages. To this end regular gauging stations have been established as follows: On the Dan and Staunton rivers at Clarksville, Va., and on the Roanoke at the crossing of the Norfolk and Carolina railroad near Neals in North Carolina; on the Tar at Tarboro, N. C.; on the Cape Fear at Fayetteville, and on the Deep and Haw rivers at Moncure, N. C.; on the Yadkin at the Southern railroad crossing near Salisbury and at Blalock's ferry, a short distance from Norwood; on the Catawba at Catawba, N. C., and at the crossing of the Southern railroad between Fort Mill and Rock Hill, S. C.; on the Broad near Blacksburg, S. C., and at Alston, S. C.; on the Saluda river at the crossing of the P. R. & W. C. R. R. near Waterloo, S. C.; on the French Broad river at Asheville, N. C.; on the Tuckaseegee river at Bryson City, N. C.; on the Little Tennessee river at Judson, N. C., and on the Hiwassee river at Murphy, N. C.

Thus it is seen that from one to two gauging stations have been established on every main stream in North and South Carolina where there is any possibility of waterpower development. Stations have not been located on the tributary streams for the reason that such stations would be of only local utility, and the data gained from the station on the main stream can be applied to solve the problem of the flow from each one of its tributaries.

In order that accurate results may be obtained at any station certain conditions must be filled. The course of the river must be straight for some distance above and below the point where it is proposed to make the gauging; the current velocity should be neither too great nor too small, as in neither case does the meter give its best results, and this velocity should be well distributed across the stream, which should be of moderate depth, flowing over a smooth bottom that is permanent and not subject to change of form through high water or other means, so that the relation between the gauge height and the area of the cross-section may be constant, and the banks should be of such height as to keep the river between them even during floods. When it is desired to establish a station on any stream, search is made for some locality which fulfills the requirements noted above, and is, in addition, so located as to be easily accessible, preferably where some bridge crosses the stream at right angles to its course, or at some ferry. When such a place is found, a permanent gauge is set up, an observer employed to take daily readings of the stage of the water-surface and the series of instrumental gaugings is begun.

The gauges which have been installed are of two classes, both consisting primarily of a strip of wood, painted white and graduated into feet and tenths and sufficiently long to measure the height of the extreme flood volume of the stream. In one form of the gauge this rod is securely spiked or bolted in a vertical position to the side of a bridge-pier or similar object so that it cannot be carried away by the water, and so that its lower end will be constantly immersed in the water. The gauge height is then read directly from the position of the water-surface on the rod. In the other form of gauge the rod is nailed or screwed in a horizontal position to the railing or guard rail of a bridge. A short distance from the end of the rod and in the same horizontal line is fastened a small pulley, and through this runs a flexible wire rope carrying a weight of from 3 to 5 pounds at its end. At an appropriate distance from the lower end of this weight there is fastened to the wire rope a small pointer of brass or copper wire. When it is desired to take a reading of the water-level, the weight is lowered by means of the wire rope until the lower end is seen to just touch the surface of the water and the place on the rod indicated by the pointer is noted. This will then be the gauge-reading, and this may be estimated to a hundredth of a foot with ease and accuracy.

These gauge rods are referred to bench marks well out of the reach of the highest floods, so that they may be replaced when they are torn out, as they are sure to be.

METHOD OF GAUGING THE FLOW OF STREAMS.

In measuring the flow of a stream it is to be remembered that the flow varies from time to time. The measurement made on any given day while the river keeps a steady flow for an hour or two is good only for that day and hour and for times when the river is at the same stage. A small rise in the stream is accompanied by a large increase in the flow, and a small fall by a large decrease in the flow. To ascertain the flow during a considerable period of the time and thus obtain an average for varying stages, two distinct classes of measurements are necessary: First, the amount of flow corresponding to each and every stage; second, a continuous record of the rise and fall. The method by which this last is secured has just been given.

There are four methods of gauging the flow of a stream: By weirs; by floats; by formula; by meters.

Weirs are practicable and economical only in the case of small streams at low water, and in such case the system is preferable to all others.

Gauging by floats is the crudest and most unreliable of all methods. It consists in throwing floating objects into the water and noting the length of time occupied by the float in moving through a measured distance down the stream. The distance divided by the time is the mean velocity of the motion of the float. But this velocity of the float is not the velocity of the stream, which varies at different points in the width and at different depths. As a rough-and-ready rule, the mean velocity of the stream is taken as about four-fifths of the velocity of the float. This is no doubt a fair approximation when the cross-section of the stream is symmetrical, the current smooth, regular, and free from eddies, and its course free from obstructions. But in small or medium-sized rivers such conditions are rare, and the whole method of measuring is liable to great uncertainty and is impracticable in large rivers.

Gauging by formula is based on the assumption that, with a given cross-section, the mean velocity of the flow bears a certain relation to the declivity down which the water flows. This may be obtained with the spirit-level, but this method is of very limited utility.

GAUGING WITH THE CURRENT METER.

Gauging by a current meter is the most satisfactory and complete method of all. A current meter is a mechanical contrivance so arranged that by lowering it into a stream the velocity of the current at any point below the surface can be obtained with accuracy by a direct reading of the number of revolutions of a wheel made to revolve by the force of the current, and a comparison of this with a table of corresponding velocities. A great many forms of current meters have been designed and used, the three general classes being the direct recording meter, in which the number of revolutions is indicated directly on a series of small gear-wheels driven by a cog-wheel connected with the revolving head of the meter; the electric meter, in which the counting is done by a simple make-and-break circuit, the registering device being placed at any convenient distance from the meter; and the acoustic meter, in which the counting is done by hearing through an ear-tube the clicks made by the revolution of a wheel and counting the same. The electric meter is the form of meter most used by the Geological Survey, and it has been found that results of a high degree of accuracy may be obtained by the careful use of this instrument. The velocity at any depth is readily obtained, and hence the problem of finding the mean velocity in any vertical is made a very simple one.

The method of making the gauging is as follows:

The width of the stream from bank to bank at the water-surface is accurately measured, and at regular intervals of 10 or 20 feet in the case of large streams, of 5 feet for smaller ones, soundings are taken by means of a heavy weight and line to determine the depth.

At each of these places where the soundings are taken the meter is run to determine the velocity in that vertical plane. This mean velocity is found in one of several ways.

In streams having a depth of 5 feet or less it has been customary to take observations at a distance below the surface sufficient to immerse the meter approximately 0.5 of a foot, and at a distance above the bottom sufficient to allow the wheel to turn freely. With meters having large lead weights, the center of the wheel is usually about 0.8 foot above the bottom. The average of the velocities thus determined is thus assumed to represent the average velocity at this portion of the river. In deeper rivers the attempt is usually made to determine the velocity at points near the surface and at intervals of about 5 feet to the bottom, the mean velocity being obtained by averaging these.

It has also been ascertained that the velocity at a depth down from the surface, equal to 0.6 of the total depth, represents very accurately the true mean velocity in that vertical. The mid-depth velocity may be gotten and 98 per cent. of it be used as the mean.

Taking, therefore, the average velocity in the vertical plane as obtained in either of these ways, this is assumed to represent the average velocity of the stream for a distance on either side of the point of observation equal to half the distance to the points of observation on either side.

The mean depth in any sub-section is taken, in the case of a broad, smooth channel, as the depth where the meter is run, or as an average obtained by adding to the depth of the water half-way to the point of observation on either side, twice the depth at the point where the meter is run and dividing the sum by four. This mean depth in feet, multiplied by the width of the sub-section in feet, gives the area of the sub-section in square feet. The area multiplied by the velocity in feet per second gives the discharge of the sub-section in cubic feet per second, and the sum of the discharges of the sub-sections is the discharge of the river.

THE RATING CURVE.

Since in the eastern United States these gaugings are primarily to aid in planning waterpower development in the future by furnishing accurate knowledge of the flow of the streams, the low stages of the water are carefully watched and accurately gauged. High-flood measurements are taken where possible, the object of the gaugings being the construction of a station rating-table or series of tables showing the relation between the gauge height of the river and the discharge at any time. In order to do this it is of course necessary to obtain the discharge at various stages of water covering the ordinary range of fluctuation. This is a comparatively simple matter if the channel does not change. The simplest method of procedure in constructing a rating-table is to plot on rectangularly-ruled paper each point representing the gauge height and discharge for a given measurement, the vertical distance from the bottom line being taken to represent the height of the water at the time the measurement was taken, and the distance from left to right the discharge in cubic feet per second. If there are a half dozen or more of these points well distributed according to height of water, it will usually be found that they will lie approximately in the path of a parabolic curve. This curve can be sketched through or near the points, the hydrographer, from his intimate knowledge, giving greater weight to some points than others, and this curve will then show the relation of gauge height to discharge for the period under consideration.

The rating-table is the numerical expression for the curve above described. In order to make this table it is simply necessary to read off the figures from the drawing, starting with the lowest value in the lower left-hand corner of the drawing. To do this the lowest horizontal line representing a tenth of a foot is followed from left to right until it intersects the curve. The value represented by this distance is set opposite the tenth of foot taken. The line representing the next higher tenth of a foot is again followed out, and its length from the margin at the left to the curve on the right is also obtained and so on, setting opposite each tenth of a foot the corresponding value of the discharge. When a table has been prepared in this way it will be found that there is an increasing value for the discharge, and that the difference between the values is also constantly increasing. Owing, however, to the small scale on which such a sketch is necessarily made, the figures read off from the drawing do not always have this constantly increasing value, some being too large, others proportionally too small. In order, therefore, to smooth out this curve it is convenient to set off between the lines of the rating-table the difference in quantities of discharge, making a third column. On running the eye down this column, several points are quickly detected where the differences are not regular. It will be seen that a slight adjustment of the differences and the addition or subtraction of a small amount from the figures of discharge will smooth out these irregularities. This should be made, and as a check upon the accuracy of the work the resulting figures should be plotted on the original drawing to determine by inspection that the rating-table as finally adjusted is accordant with the original observations. This method of graphic construction avoids difficulties and liability to blunder in the use of the higher mathematics, and its accuracy is well within that of the original data (see fig. 29, p. 310, for an example of this method of construction).

The question now arises for how long a period will this rating-table be true, or its values fall within the limits of allowable error? Every river is constantly modifying its channel to some extent, alternately cutting it away and filling it in to suit the ever-varying conditions of velocity. The station is, in the first instance, so located that this action will be a minimum, but usually there is an appreciable change, especially during or after a flood or a protracted period of low water.

The rating curve is founded as far as possible on measurements under all the varying conditions of depth of water, and is in itself of the nature of an average of these conditions. Thus it is evident for any height of water for a particular stage of the river the discharge, as given by the rating-table, may not be as accurate as the result of a careful gauging made on that day, but the value given by the rating-table should be an average value of the discharge for that particular height, whether the river is rising, falling or stationary. In other words, it is assumed for a given height of water the discharge may vary between certain limits, dependent upon circumstances such as the amount of silt carried, condition of channel above and below, and other modifying conditions, and the rating-tables cannot be expected to discriminate between these conditions but must represent the average between them.

In this connection it may be interesting to note the following laws governing the flow of water in river channels which were deduced by Humphreys and Abbott in their experiments on the Mississippi river, and which, paradoxical as they may appear, are in perfect accordance with the laws governing flowing water. (See page 324, Physics and Hydraulics of the Mississippi river.)

1. For any given level there is much more water passing when the river is rising than when it is falling.
2. At any given gauge reading, there is usually more water passing in a long and rapid than in a short and slow rise; but this is not always the case, the discharge being governed by the relative stage of the water in the channel above and below.
3. The maximum discharge, in any normal rise, occurs when the river has reached a point a few inches below the highest point attained.
4. If, when a freshet has culminated, and the water either comes to a stand or begins to fall, a second rise occurs, it will cause the surface to rise considerably higher than would have been the case had the same volume passed without a previous diminution of supply.

It is therefore to be borne in mind that the maximum discharges of two floods are not necessarily proportional to the relative water-levels attained by them. Under some circumstances the lesser discharge may cause the higher water-mark.

CALCULATION OF POWER.

From such a table the flow corresponding to any given gauge height may be easily taken out. The flow of the stream may then be calculated as follows:

In the tables of mean daily gauge heights the values of the discharge as taken from the rating-table are set opposite the several gauge heights. The mean flow for the month in cubic feet per second is then found by dividing the sum of all the daily discharges by the number of days in the month. The terms "maximum" and "minimum" discharge explain themselves. It may be well to note, however, that these quantities are daily averages, and that it may be possible that at some time during the day very much more or considerably less water was passing than is shown in the tables.

From the flows as thus determined it is a matter of simple multiplication to determine the total theoretical horsepower per foot fall at the station where the gaugings are made. A theoretical horsepower is an energy of 33,000 foot-pounds per minute, or of 550 foot-pounds per second. A cubic foot of river water may be taken to weigh 62.45 pounds. As an example of the calculation of the power from the flow, suppose a stream is discovered to discharge 100 cubic feet per second. This quantity, multiplied by 62.45, gives the total weight of water passing the section every second, and this total weight divided by 550, the foot-pounds of energy per second necessary to give one horsepower, gives 11.35, the theoretical horsepower of the stream per foot of fall. In practice this process may be somewhat shortened by multiplying the quantity of water in cubic feet per second by 0.1135, which will give the theoretical horsepower direct. The actual horsepower which can be obtained will range from 70 to 84 per cent. of the theoretical, according to the efficiency of the motor employed. This may be obtained approximately by multiplying the discharge in cubic feet per second by 0.087, corresponding to an efficiency of 77 per cent. in the motor.

The approximate theoretical power at other points on the same stream may be estimated by a simple comparison of the areas draining past the places, it being assumed that all the area has an equal rate of flow per square mile and that, therefore, the power at any two points on the stream is simply proportional to the areas drained past the points. Strictly speaking this is not true, since the discharge per square mile from any drainage area increases as the head of the stream is approached, but the law of the increase is not well known. Any error thus introduced will, however, be on the side of safety, giving the discharge as smaller than it should be.

THE AVERAGE FLOW OF A STREAM.

At first sight it would seem that, knowing the daily discharges of a stream throughout the year, the question of its average flow would be an easy one to answer, but it is soon seen that a variety of answers may be given. By an examination of the discharge diagrams given in this report (pp. 289 to 334), it will be seen that the streams fluctuate so widely in the amounts of water flowing in them from day to day or from year to year that they cannot be said to flow with anything like regularity for any appreciable length of time, except during summer droughts, when for a time the stream gradually sinks lower and lower or maintains its flow within small limits for a considerable period. An average flow for such a period may be readily obtained, but it will not be applicable for the whole year, though such an average is unquestionably of value in determining the waterpower of a stream.

In the computations of the discharge given further on, the mean flow has been estimated by months and from this by years, but this does not fulfil the conception of average flow since it includes flood gaugings and is notably increased thereby.

An arbitrary method has been suggested by Mr. Leslie[1] for computing the "average summer discharge" or "ordinary" flow of a stream from the daily gaugings, as follows:

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[1] Minutes of Proceedings of the Institution of Civil Engineers, vol. x, p. 327, quoted by Fanning, Water Supply and Hydraulic Engineering, 9th ed., p. 80.

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"Range the discharges as observed daily in the order of their magnitude.

"Divide the list thus obtained into an upper quarter, a middle half and a lower quarter.

"The discharges in the upper quarter of the list are to be considered as *floods*, and in the lower quarter as *minimum flows.*

"For each of the gaugings exceeding the average of the middle half, including flood gaugings, substitute the average of the middle half of the list, and take the mean of the whole list, as thus modified, for the *ordinary* or *average discharge, exclusive of flood waters.*"

Fanning notes that this rule applied to the discharge of several New England streams gave results varying from one-fourth to one-third of the mean flow, including floods.

This rule was applied to the daily discharges of the Yadkin river at Norwood, N. C., for 1898, giving as the average flow, excluding floods, 3,937 cubic feet per second, while the mean flow for the year, including floods, was 5,432 cubic feet per second. It will be noted, however, that during this year the floods on this stream were relatively infrequent and generally small in volume.

VALUE OF THESE MEASUREMENTS.

While measurements of this sort extending over only a short period are of value, it is obvious that the value increases vastly as the time over which they extend is increased, since in the longer period there is the greater probability that the extremes of the conditions producing variations in the flow will be met with, that the abnormal years and seasons will occur as well as the normal years and seasons, and that thus a more accurate knowledge of the flow under all the conditions which effect it will be obtained.

The stages of flow of most interest to those who have to do with waterpower are the *minimum flow,* or that quantity which is permanently available even during the most severe and long-continued droughts; and that stage of flow which may be called the *low season flow of dry years,* and which can be depended on at all times save on a few days in the dryest seasons of the dryest years when the flow is approaching its absolute minimum (see pp. 54 to 58). These low stages of flow are only maintained for short periods of time, but they represent the power which can be depended upon as limited above, and it becomes a question to be solved by economical considerations whether any construction shall be planned requiring more power than these stages of flow will yield. If part of the machinery can economically remain idle for a part of the time, then such a development can be made, otherwise auxiliary steam or electrical power must be secured to supply the deficiency during the dry seasons.

In general, the knowledge of these stages of flow cannot be obtained by a short series of observations, but it seems that these measurements were begun in the South Atlantic states at a time very favorable for obtaining these stages of flow or certainly a very close approximation to them.

THE DROUGHT OF 1897.

The flow of a stream is primarily dependent on the precipitation on the drainage basin, but the year of minimum rainfall is not necessarily the year when the streams will attain their lowest stages of flow. Variability of flow depends largely on the distribution of the rainfall throughout the year. The average yearly flow will be least in the year when least rain falls, but the average flow for a period of from one to three months in the year when the rainfall is near or even a little above the normal may be less than for any similar period in the year of minimum rainfall. A period of several months may occur when the evaporation is large, the quantity of water absorbed by vegetation is large also, the sub-surface supply which tends to regulate the flow of the stream has been drawn down in previous periods of drought, and very little rain falls, then, in such a period as this, the streams will attain a very low stage of flow only possible when some such series of circumstances all act together to this end. When, in addition to this, the year when such a condition occurs is also the year of minimum rainfall, then the streams in the region thus affected will attain the lowest possible stage of flow. It was this condition that existed in North Carolina and for the Southern states generally during 1897.

For the entire South Atlantic states the period from 1894 to 1897 inclusive was a period of less than the average rainfall, the deficiency for the area for 1896 alone amounting to 10.7 inches, and for the period of 11 years, from 1887 to 1897 inclusive, eight of these years have been years of less than normal precipitation, the deficiency varying from 10.7 inches to 1.5 inches, the greatest excess over the normal being only 2 inches in 1889.[1]

In North Carolina since 1891 there has been an annual deficiency in precipitation, only one year, 1895, showing an amount above the normal, and, according to the testimony of numerous persons, during all this time the level of the underground waters as shown by wells and springs, was gradually sinking, reaching in September and October of 1897 the lowest point certainly in a quarter of a century.

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[1] Bull. D., U. S. Dept. Agr. Weather Bureau, p. 9.

The drought beginning in August, 1897, was the most severe in the history of the state, and caused the lowest stages of the rivers ever known. For the month of September the precipitation was the next smallest on record for that month, amounting to an average of 1.47[1] inches for the entire state.

During the month of October, 1897, many of the rivers attained a stage of flow even lower than in September, for the very dry period was not broken till the last half of the month, and the demands of the vegetation and evaporation being greater than the supply, and the subsurface water-level having been drawn down, the rivers continued to fall. The following table, giving the monthly average precipitations at all stations in North Carolina, shows that the rainfall in this state for 1897 was less than the normal by 5.91 inches, and that this year was the dryest year with one exception, 1872, in all the time covered by the records of the Weather Bureau, a period of over 26 years. Thus all the conditions for a period of minimum stream-flow were fulfilled, and it seems improbable that the flow will ever fall very much lower than in this year.

PRECIPITATION IN NORTH CAROLINA.

Monthly averages for entire area.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1872	1.96	4.76	4.42	2.42	3.82	4.23	4.02	5.40	3.29	3.85	2.73	4.65	45.55
1873	4.99	9.03	2.87	1.76	7.11	3.50	4.55	7.14	4.37	3.11	3.70	3.49	55.62
1874	4.49	4.99	4.30	7.96	3.58	4.09	6.11	5.73	5.58	1.68	3.30	2.83	54.64
1875	4.81	4.93	7.20	4.74	2.52	4.29	5.84	7.45	3.54	3.18	3.96	4.40	56.36
1876	1.72	3.70	5.20	3.09	4.28	5.80	4.95	5.44	8.35	3.87	2.67	3.53	52.10
1877	3.97	1.91	6.29	6.91	2.56	4.84	6.52	5.37	10.13	5.55	5.53	5.30	64.88
1878	6.32	3.09	2.23	5.05	4.92	4.09	3.57	8.56	4.00	5.36	3.46	6.28	56.88
1879	4.63	3.68	3.80	3.71	3.48	2.14	5.70	7.52	3.57	3.55	3.31	4.58	49.67
1880	2.59	3.23	6.63	3.91	2.03	3.56	6.49	7.96	3.53	3.62	6.75	3.98	54.28
1881	4.65	4.15	4.31	4.39	2.34	4.10	4.65	2.91	3.57	3.86	4.36	4.88	48.17
1882	7.50	4.54	5.41	3.97	3.29	2.87	5.34	5.98	5.45	4.60	2.74	3.81	55.50
1883	7.82	3.44	5.16	6.99	3.35	6.74	3.12	3.45	7.25	3.21	2.60	2.96	56.09
1884	5.90	5.66	8.50	3.31	2.75	5.66	5.93	3.90	2.04	0.81	3.08	6.77	54.31
1885	5.78	3.79	2.58	2.28	6.61	4.04	4.03	4.08	3.49	6.05	4.32	4.15	51.20
1886	4.45	2.31	5.46	3.08	5.15	7.20	7.41	6.80	2.28	0.84	3.00	3.86	51.84
1887	3.30	3.92	3.22	2.84	4.45	4.02	6.13	9.89	2.11	6.72	1.29	4.70	52.09
1888	4.15	4.25	6.33	1.74	7.04	3.11	3.26	4.66	9.06	4.64	3.38	3.36	54.98
1889	5.26	3.72	2.89	3.63	4.62	5.91	7.73	5.55	4.04	2.48	4.31	0.59	50.73
1890	1.41	4.20	3.40	2.75	4.79	2.83	7.19	6.36	5.33	4.29	0.35	3.59	46.49
1891	4.66	5.70	7.70	2.37	5.38	3.69	6.75	8.23	2.11	2.55	3.07	2.34	54.55
1892	6.05	3.35	3.30	3.98	3.57	6.68	5.78	3.84	3.48	0.59	3.66	2.81	47.04
1893	2.91	5.41	2.81	3.58	5.57	5.74	4.01	7.18	5.61	5.54	2.77	3.13	52.66
1894	3.91	4.82	2.05	1.75	4.00	2.62	6.07	6.13	4.77	5.50	1.42	3.53	46.57
1895	6.41	2.42	5.27	7.35	4.83	3.53	5.25	5.50	1.25	1.86	3.15	3.41	50.23
1896	2.79	5.64	2.59	1.99	4.28	5.86	8.19	2.81	5.81	1.90	4.67	2.51	47.54
1897	2.30	5.90	5.56	3.68	3.78	3.99	5.60	3.41	1.47	3.99	2.89	3.67	46.19
1898	2.63	1.03	4.02	3.70	3.69	3.41	6.98	7.94	4.24	6.42	3.24	2.74	50.04
Normals	4.35	4.21	4.56	3.77	4.21	4.37	5.58	5.85	4.41	3.67	3.32	3.80	52.10

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[1] Climate and Crops, U. S. Dept. Agr., N. C. Section, 1897. p. 3.

The dryest month of which there is any record was November, 1890, when the precipitation for the entire state was only 0.35 inch, and the rainfall for this year was but very little more than fell in 1897, but the years that preceded were years of more than average rainfall, and so the underground supply had been kept up and was ready to be drawn upon to maintain the flow of the streams at about the normal low-water flow.

This table also shows the amount and the distribution of the rainfall in North Carolina. It is seen that the precipitation is large in amount, well distributed throughout the year, the dryest months occurring in October and November, and that periods of drought are rare and of short duration. Since the rainfall is large, we are led to expect a large annual flow in the streams, and since the dryest periods fall at a time when the demands of plant life and of evaporation are still great, we are led to expect a variable flow and such is the case, all the rivers in North Carolina on which there is any waterpower being subject to periods of low flow and to violent freshets. Any hydraulic construction on any of these streams needs be as firmly founded as the hills themselves, else some day its ruins will go dashing along toward the ocean on the crest of some flood wave.

CHAPTER XV.

RESULTS OF STREAM MEASUREMENTS.[1]

UNITS OF MEASUREMENT.

The results of the stream measurements shown in the following pages are expressed in second-feet, this having been found to be the most convenient unit in which to express the discharge of rivers. A second-foot of water may be defined as a stream of one foot wide and one foot deep, flowing with a velocity of one foot per second.

The unit of quantity or of capacity employed is the acre-foot, equivalent to that quantity of water which, if spread out over an area of one acre, would cover it to a depth of one foot. This is equal to 43,560 cubic feet. There is a convenient connection between these units. One second-foot flowing for 24 hours will deliver 86,400 cubic feet of water, equivalent to nearly 2 acre-feet (more exactly, 1.983471 acre-feet). Many engineers are still inclined to use the million gallons as the unit of storage, as this is well fixed in computations relating to municipal supply. For convenience, it may be stated that one acre-foot equals 325,851.45 gallons, or a little less than a third of a million gallons.

In the following tables the maximum, minimum and mean quantity in the streams each month are given in second-feet and the total discharge in acre-feet. To obtain this total for the month in acre-feet it is the usual practice to multiply the mean daily discharge in second-feet by a factor which is the product obtained by dividing the number of seconds in each month by the number of square feet in an acre. For a month containing 31 days this factor is 61.49; for a month of 30 days it is 59.50; for a month of 29 days it is 57.52; and for a month of 28 days it is 55.54.

The depth of run-off over the whole basin is also given for each month in inches for convenience of comparison with the rainfall, and also in cubic feet per second for every square mile of drainage area. The former is obtained by multiplying the acre-feet per month by 12 to obtain acre-inches and dividing this by 640, the number of acres in a square mile and also by the number of square miles in the drainage basin. The run-off in second-feet per square mile is simply the mean monthly discharge divided by the total area of the basin in square miles, the whole area being assumed to discharge at a uniform rate. The mean discharge for the year is taken to be the average of all the mean monthly discharges, and the total quantity of run-off is the sum of the monthly run-offs.

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[1] By E. W. Myers.

CLARKSVILLE STATION, ON THE DAN AND STAUNTON RIVERS.

At Clarksville, Virginia, the Dan and Staunton rivers unite, forming the Roanoke. The Southern railway bridge crosses the river about one thousand feet above the junction, the sections being suitable for measurement at both points.

About four miles above the junction of the Dan and Staunton rivers is a cut-off, apparently occupying an old channel, diverting water from the Dan to the Staunton. At its mouth is a shoal or riffle about 70 feet long, the water being on December 4, 1895, about one foot deep and having an estimated velocity of approximately 3 feet per second, giving a total discharge from the Dan to the Staunton of 200 second-feet. The average width of the water surface in the channel was 150 feet. The total fall between the two rivers was estimated to be approximately 2 feet, this being principally at the riffle at the mouth of the channel. The total length of the channel was about 1000 feet. This cut-off, by carrying water from the Dan, vitiates the separate computations of discharge made, but does not affect the total discharge for the Roanoke.

Gauging stations were established on the Dan and Staunton rivers at Clarksville on October 28, 1895. On Dan river the gauge is fastened to the inside of the guard-rail of the fourth panel of the third span west of the Southern railroad bridge. The distance from the zero of the rod to the outside of the pulley-wheel is 3 feet; the length of the wire rope is 33.17 feet. The waterpower of Dan river has been developed to a considerable extent at Danville. An examination at points above showed that the dams at Danville pond the water, and, as a result, modify the natural characteristics of the stream.

The gauge on the Staunton river is fastened to the inside of the guard-rail of the fourth panel of the third span from the west. The distance from the zero of the rod to the outer rim of the pulley-wheel is 3 feet; the length of the wire gauge is 33 feet; the distance of the top and upper end of the third floor beam of the second span from the west from the water surface was 27.15 feet when the gauge height was 0.25 foot. The distance from the east abutment of the Dan river bridge to the west abutment of the Staunton river bridge is 165 feet. The tables of daily gauge heights for these stations will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON DAN RIVER AT CLARKSVILLE, VIRGINIA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Oct. 2	C. C. Babb	29	0.38	591	1.31	773
2	Oct. 28	....do	29	0.65	719	1.44	1,032
3	Dec. 5	....do	62	1.12	865	1.60	1,382
	1896.						
4	Apr. 22	E. W. Myers	21	1.90	1,209	1.89	2,291
5[1]	May 26	....do	21	1.77	1,465	1.47	2,155
6	July 15	....do	21	2.97	1,932	2.39	4,626
7	Sept. 15	A. P. Davis	68	1.17	953	1.50	1,433
	1897.						
8	Feb. 25	E. W. Myers	2154	12.32	7,443	3.49	26,015
9	Mch. 18	....do	2154	4.20	2,867	2.70	7,755
10	Sept. 29	....do	2154	0.10	797	1.07	856
	1898.						
11	Jan. 8.	E. W. Myers	2154	1.05	1,138	1.76	2,009

RATING-TABLE FOR DAN RIVER AT CLARKSVILLE, VIRGINIA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
0.00	590	3.20	4,800	6.20	12,650	9.40	21,350
0.20	700	3.40	5,250	6.40	13,200	9.60	21,900
0.40	825	3.60	5,725	6.60	13,750	9.80	22,450
0.60	965	3.80	6,225	6.80	14,300	10.00	23,000
0.80	1,115	4.00	6,725	7.00	14,800	10.20	23,550
1.00	1,280	4.20	7,225	7.20	15,350	10.40	24,100
1.20	1,450	4.40	7,725	7.40	15,900	10.60	24,650
1.40	1,645	4.60	8,250	7.60	16,450	10.80	25,200
1.60	1,880	4.80	8,800	7.80	17,000	11.00	25,750
1.80	2,130	5.00	9,250	8.00	17,550	11.20	26,300
2.00	2,425	5.20	9,800	8.20	18,100	11.40	26,850
2.20	2,725	5.40	10,350	8.40	18,650	11.60	27,400
2.40	3,075	5.60	10,900	8.60	19,200	11.80	27,950
2.60	3,525	5.80	11,450	8.80	19,750	12.00	28,500
2.80	3,925	6.00	12,100	9.00	20,300	12.20	29,050
3.00	4,350	...	......	9.20	20,800	.....	.....

ESTIMATED MONTHLY DISCHARGE OF DAN RIVER AT CLARKSVILLE, VIRGINIA.

[Drainage area, 3798 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
February	20,163	2,091	5,070	291,626	1.48	1.37
March	17,245	2,231	4,935	303,453	1.53	1.33
April	24,017	2,091	4,777	284,231	1.44	1.29
May	7,650	1,255	2,715	166,940	0.84	0.73
June	5,900	1,255	2,145	127,636	0.64	0.58
July	[2]33,000	1,131	4,800	295,152	1.49	1.29
August	2,605	839	1,204	74,034	0.37	0.32
September	10,542	825	1,373	81,696	0.41	0.37
October	20,218	1,131	1,856	114,125	0.58	0.50
November	14,620	1,251	2,260	134,470	0.68	0.61
December	8,855	1,469	2,365	145,424	0.72	0.63
	33,000	825	3,050	2,018,784	10.18	0.82

[1] For measurement No. 5 channel had cut out badly, averaging almost all way across a cut of 1 foot.

[2] Estimated.

RATING-TABLE FOR DAN RIVER AT CLARKSVILLE, VIRGINIA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
—1.50	400	0.40	890	3.80	6,704	7.50	15,066
—1.40	420	0.60	990	4.00	7,156	8.00	16,196
—1.30	440	0.80	1.100	4.20	7,608	8.50	17,326
—1.20	460	1.00	1,240	4.40	8,060	9.00	18,456
—1.10	480	1.20	1,400	4.60	8,512	9.50	19,586
—1.00	500	1.40	1,620	4.80	8,964	10.00	20,716
—0.90	520	1.60	1,900	5.00	9,416	10.50	21,846
—0.80	540	1.80	2,250	5.20	9,868	11.00	22,976
—0.70	560	2.00	2,636	5.40	10,320	11.50	24,106
—0.60	580	2.20	3,088	5.60	10,772	12.00	25,236
—0.50	600	2.40	3,540	5.80	11,224	12.50	26,366
—0.40	620	2.60	3,992	6.00	11,676	13.00	27,496
—0.30	645	2.80	4,444	6.20	12,128	13.50	28,626
—0.20	670	3.00	4,896	6.40	12,580	14.00	29,756
—0.10	700	3.20	5,348	6.60	13,032	.....	......
0.00	730	3.40	5,800	6.80	13,484	.....	......
0.20	810	3.60	6,252	7.00	13,936	.....	......

ESTIMATED MONTHLY DISCHARGE OF DAN RIVER AT CLARKSVILLE, VIRGINIA.

[Drainage area, 3798 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	7,269	1,135	2,565	157,715	0.78	0.68
February	27,044	2,340	9,212	511,610	2.53	2.43
March	10,998	2,749	6,030	370,770	1.83	2.59
April	7,382	1,820	3,481	207,135	1.02	0.92
May	10,094	1,900	5,014	308,298	1.52	1.32
June	2,075	1,100	1,326	78,902	0.39	0.35
July	3,201	1,045	1,404	86,330	0.43	0.37
August	1,320	830	984	60,504	0.30	0.26
September	890	730	755	44,926	0.22	0.20
October	4,896	400	1,609	98,933	0.48	0.42
November	10,320	750	1,703	101,335	0.50	0.45
December	7,382	990	2,231	137,180	0.68	0.59
The year	27,044	400	3,026	2,163,638	10.68	0.80

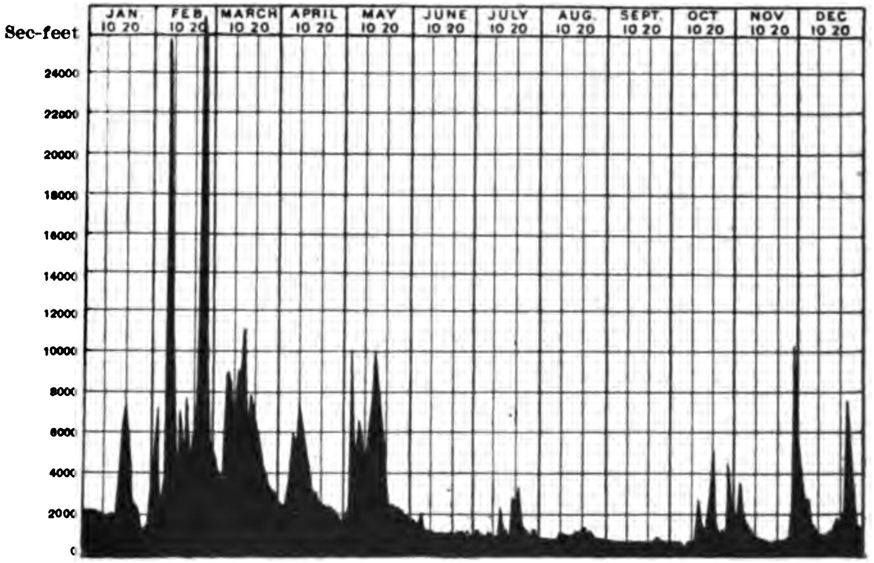

FIG. 17.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE DAN RIVER AT CLARKSVILLE VA. FOR 1897. (U. S. G. S.)

LIST OF DISCHARGE MEASUREMENTS MADE ON STAUNTON RIVER AT CLARKSVILLE, VIRGINIA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second feet).
	1895.						
1	Oct. 3	C. C. Babb	29	0.07	550	0.97	533
2	Oct. 28	....do	76	0.28	659	1.31	861
3	Dec. 5	....do	62	0.61	917	1.25	1,151
	1896.						
4	Apr. 22	E. W. Myers	21	1.37	1,256	1.58	1,971
5	May 26	....do	21	1.14	1,401	1.39	1,956
6	July 15	....do	21	2.64	1,890	2.25	4,252
7	Sept. 15	A. P. Davis	68	—0.06	723	1.03	748
	1897.						
8	Feb. 25	E. W. Myers	2154	11.95	7,250	4.03	29,259
9	Mch. 18	....do	2154	3.68	2,838	2.93	8,326
10	Sept. 29	...do	2154	—0.25	610	1.25	763
	1898.						
11	Jan. 8	E. W. Myers	2154	0.70	992	1.97	1,969

RATING-TABLE FOR STAUNTON RIVER AT CLARKSVILLE, VIRGINIA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
0.00	685	1.40	2,095	5.00	10,100	8.60	20,200
—0.10	630	1.60	2,395	5.20	10,650	8.80	20,800
—0.20	580	1.80	2,715	5.40	11,200	9.00	21,400
—0.30	535	2.00	3,050	5.60	11,750	9.20	22,000
—0.40	500	2.20	3,395	5.80	12,300	9.40	22,600
—0.50	470	2.40	3,760	6.00	12,850	9.60	23,200
—0.60	440	2.60	4,150	6.20	13,400	9.80	23,800
—0.70	410	2.80	4,600	6.40	13,950	10.00	24,400
—0.80	380	3.00	5,100	6.60	14,500	10.20	25,000
—0.90	350	3.20	5,600	6.80	15,050	10.40	25,600
—1.00	330	3.40	6,100	7.00	15,600	10.60	26,200
0.00	685	3.60	6,600	7.20	16,180	10.80	26,800
0.20	820	3.80	7,100	7.40	16,660	11.00	27,400
0.40	980	4.00	7,600	7.60	17,240	11.20	28,000
0.60	1,160	4.20	8,100	7.80	17,820	11.40	28,600
0.80	1,350	4.40	8,600	8.00	18,400	11.60	29,200
1.00	1,560	4.60	9,100	8.20	19,000	11.80	29,800
1.20	1,810	4.80	9,600	8.40	19,600	12.00	30,400

ESTIMATED MONTHLY DISCHARGE OF STAUNTON RIVER AT CLARKSVILLE, VIRGINIA.

[Drainage area, 3546 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
February	19.660	1,852	4,554	261,946	1.42	1.32
March	16,554	1,852	3,084	189,635	1.02	0.89
April	23.890	1,732	3,990	237.405	1.28	1.15
May	7,325	916	2,240	137.737	0.75	0.65
June	5.450	680	1,608	95,682	0.52	0.46
July	[1]36,000	828	3,611	222.040	1.20	1.04
August	2,459	635	860	52,881	0.28	0.24
September	3,899	645	1,150	68,425	0.37	0.33
October	19,900	892	1,620	99,614	0.54	0.47
November	14,005	1,023	1,979	117,850	0.63	0.57
December	5.125	1,245	2,008	123,472	0.67	0.58
	36.000	635	2,427	1.606.687	8.68	0.70

[1] Estimated.

RATING-TABLE FOR THE STAUNTON RIVER AT CLARKSVILLE, VIRGINIA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
−0.70	540	1.80	3,496	5.00	11,560	8.20	19,624
−0.60	560	2.00	4,000	5.20	12,064	8.40	20,128
−0.50	580	2.20	4,504	5.40	12,568	8.60	20,632
−0.40	600	2.40	5,008	5.60	13,072	8.80	21,136
−0.30	625	2.60	5,512	5.80	13,576	9.00	21,640
−0.20	650	2.80	6,016	6.00	14,080	9.50	22,900
−0.10	675	3.00	6,520	6.20	14,584	10.00	24,160
0.00	700	3.20	7,024	6.40	15,088	10.50	25,420
0.20	800	3.40	7,528	6.60	15,592	11.00	26,680
0.40	1,000	3.60	8,032	6.80	16,096	11.50	27,940
0.60	1,220	3.80	8,536	7.00	16,600	12.00	29,200
0.80	1,470	4.00	9,040	7.20	17,104	12.50	30,460
1.00	1,760	4.20	9,544	7.40	17,608	13.00	31,720
1.20	2,100	4.40	10,048	7.60	18,112	13.50	32,980
1.40	2,530	4.60	10,552	7.80	18,616	14.00	34,240
1.60	2,992	4.80	11,056	8.00	19,120	14.50	35,500

ESTIMATED MONTHLY DISCHARGE OF STAUNTON RIVER AT CLARKSVILLE, VIRGINIA.

Month.	Discharge.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	11,686	1,540	5,773	354,970	1.88	1.63
February	29,326	4,504	10,593	588,306	3.11	2.99
March	11,938	3,118	6,459	397,150	2.10	1.82
April	7,906	1,685	3,584	213,265	1.18	1.01
May	10,804	1,760	5,367	330,004	1.74	1.51
June	[1]8,410	[1]1,220	[1]2,301	136,920	0.72	0.65
July	3,118	900	1,378	84,730	0.45	0.39
August	1,470	720	983	60,442	0.32	0.28
September	900	625	705	41,951	0.22	0.20
October	5,008	550	1,540	94,691	0.49	0.48
November	10,804	600	1,640	97,587	0.52	0.46
December	10,300	950	2,401	147,631	0.78	0.68
The year	29,326	550	3,560	2,547,647	13.46	1.00

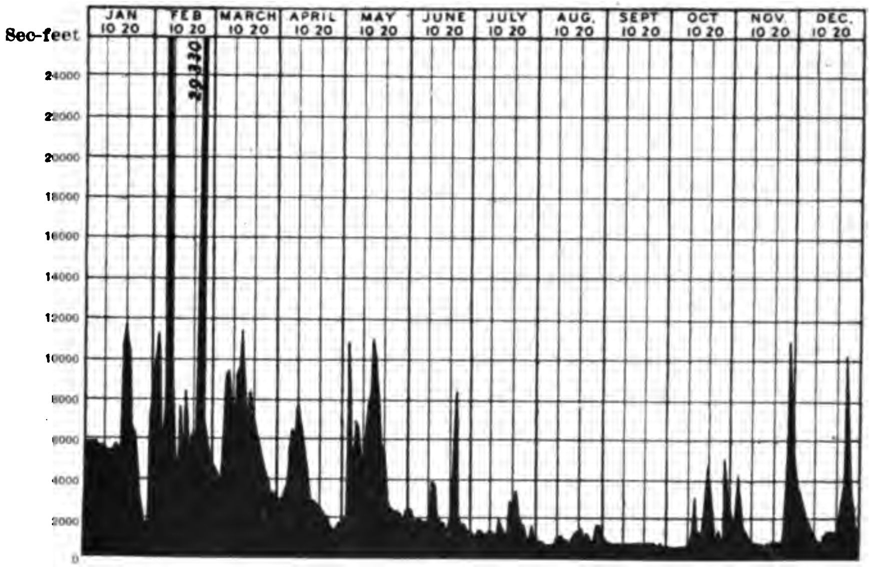

FIG. 18.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE STAUNTON RIVER, AT CLARKSVILLE, VA., FOR 1897. (U. S. G. S.)

[1] Records for month not complete.

NEALS STATION, ON THE ROANOKE RIVER.

The gauge on this stream is located on the Norfolk and Carolina railroad bridge which crosses the river near Neals station. The zero of the gauge-rod is over the center of the fourth floor beam of the second span from the north end of the bridge. The distance from the zero of the rod to the outer rim of the pulley-wheel is 2.47 feet, and the distance from the end of the weight to the pointer on the wire is 44.66 feet. The section is a fairly good one, the river being straight for some distance above and below the station and the bottom smooth, but being muddy it is apt to cut out in seasons of high water, and both banks are also subject to overflow, the river sometimes attaining a width of one and one-half miles during high rises.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON ROANOKE RIVER AT NEALS, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	July 27	E. W. Myers	2154	7.05	3,152	1.53	4.849
2	Sept. 7	....do	2154	1.31	2,148	1.21	2,610
3	Dec. 19	....do	2154	11.60	5,214	1.76	9,180
	1897.						
4	Jan. 23	E. W. Myers	2154	12.65	5,551	2.37	13,155
5	Feb. 27	....do	2154	27.95	44,666	1.44	64,132
6	Mar. 17	....do	2154	24.71	31,590	1.19	37,659
7	May 17	....do	2154	18.40	7,240	2.65	19,219
8	Oct. 1	....do	2154	1.00	1,544	1.24	1,928
	1898.						
9	Jan. 11	E. W. Myers	2154	4.43	2,606	1.65	4,334
10	May 10	....do	2154	22.50	8,140	3.42	27,880

RATING-TABLE FOR ROANOKE RIVER AT NEALS, NORTH CAROLINA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
0.00	2,000	4.20	3,300	8.40	6,060	16.50	15.950
0.20	2,020	4.40	3,400	8.60	6,240	17.00	16,750
0.40	2,040	4.60	3,500	8.80	6,420	17.50	17,565
0.60	2,060	4.80	3,600	9.00	6,600	18.00	18,400
0.80	2.100	5.00	3,700	9.20	6,780	18.50	19,310
1.00	2,140	5.20	3,805	9.40	6,960	19.00	20,300
1.20	2,190	5.40	3,915	9.60	7,140	19.50	21,380
1.40	2,240	5.60	4,025	9.80	7,320	20.00	22,500
1.60	2,290	5.80	4,135	10.00	7,500	20.50	23,720
1.80	2,340	6.00	4.235	10.50	8,000	21.00	25,000
2.00	2.400	6.20	4,355	11.00	8,500	21.50	26,320
2.20	2,475	6.40	4,465	11.50	9,040	22.00	27,700
2.40	2,540	6.60	4,585	12.00	9,600	22.50	29,190
2.60	2,610	6.80	4,705	12.50	10,190	23.00	30,800
2.80	2,680	7.00	4,850	13.00	10,800	23.50	32,570
3.00	2,750	7.20	5,010	13.50	11,460	24.00	34,550
3.20	2,830	7.40	5,180	14.00	12.150	25.00	39,200
3.40	2,915	7.60	5,350	14.50	12,860	26.00	44.800
3.60	3,005	7.80	5,520	15.00	13,600	27.00	52,500
3.80	3,100	8.00	5,700	15.50	14,370	28.00	64,300
4.00	3,200	8.20	5,880	16.00	15.150	.....	......

ESTIMATED MONTHLY DISCHARGE OF ROANOKE RIVER AT NEALS, NORTH CAROLINA.

[Drainage area 8717 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
August	4,105	2,750	3,154	193,933	0.41	0.36
September	6,510	2,400	3,217	191,424	0.41	0.37
October	39,720.	2,890	9,117	560,586	1.21	1.05
November	23,220	2,890	5,896	350,836	0.75	0.68
December	21,820	3,415	7,423	456,425	0.98	0.85
					3.76	0.66
1897.						
January	12,010	2,790	4,501	276,755	0.60 .	0.52
February	64,300	2,915	28,178	1,564,930	3.36	3.23
March	37,700	7,320	22,824	1,403,390	3.02	2.62
April	22,270	4,525	8,440	502,215	1.08	0.97
May	21,160	4,410	8,707	535,350	1.15	1.00
June	9,040	3,005	4,252	253,010	0.55	0.49
July	7,410	2,790	3,956	243,245	0.52	0.45
August	3,650	2,240	2,673	164,360	0.36	0.31
September	3,150	2,000	2,217	131,920	0.28	0.25
October	4,465	2,010	2,561	157,470	0.33	0.29
November	3,710	2,340	3,095	184,165	0.40	0.36
December	10,190	3,250	5,520	339,410	0.72	0.63
The year	64,300	2,000	8,077	5,756,220	12.37	0.93

RATING-TABLE FOR ROANOKE RIVER AT NEALS, NORTH CAROLINA, FOR 1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
1.00	2,060	4.40	3,384	8.80	6,080	18.00	18,300
1.10	2,095	4.60	3,476	9.00	6,250	18.50	19,180
1.20	2,130	4.80	3,568	9.20	6,430	19.00	20,100
1.30	2,165	5.00	3,660	9.40	6,610	19.50	21,100
1.40	2,200	5.20	3,760	9.60	6,800	20.00	22,300
1.50	2,235	5.40	3,860	9.80	7,000	20.50	23,575
1.60	2,270	5.60	3,965	10.00	7,200	21.00	24,900
1.70	2,305	5.80	4,075	10.50	7,700	21.50	26,300
1.80	2,340	6.00	4,185	11.00	8,200	22.00	27,750
1.90	2,375	6.20	4,295	11.50	8,750	22.50	29,270
2.00	2,410	6.40	4,405	12 00	9,300	23.00	30,900
2.20	2,480	6.60	4,518	12.50	9,950	23.50	32,640
2.40	2,550	6.80	4,634	13.00	10,600	24.00	34,550
2.60	2,623	7.00	4,750	13.50	11,300	24.50	36,780
2.80	2,699	7.20	4,880	14.00	12,000	25.00	39,150
3.00	2,775	7.40	5,010	14.50	12,750	25.50	41,950
3.20	2,855	7.60	5,150	15.00	13,500	26.00	45,000
3.40	2,935	7.80	5,300	15.50	14,275	26.50	49,500
3.60	3,020	8.00	5,450	16.00	15,075	27.00	54,250
3.80	3,110	8.20	5,600	16.50	15,875	27.50	59,200
4.00	3,200	8.40	5,750	17.00	16,600	28.00	64,300
4.20	3,292	8.60	5,910	17.50	17,440	......	......

ESTIMATED MONTHLY DISCHARGE OF ROANOKE RIVER AT NEALS, NORTH CAROLINA.

[Drainage area 8717 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	11,300	3,200	4,613	284,115	0.61	0.53
February	5,910	2,935	3,544	196,834	0.43	0.41
March	6,900	2,935	3,737	230,182	0.49	0.43
April	14,120	3,568	6,849	407,515	0.87	0.78
May	29,891	3,200	13,139	809,231	1.74	1.51
June	14,755	2,159	5,387	310,526	0.69	0.62
July	5,910	2,353	3,760	231,190	0.49	0.43
August	14,595	2,975	4,815	296,062	0.63	0.55
September	34,043	2,060	8,426	501,389	1.07	0.96
October	28,762	2,855	8,580	527,563	1.12	0.97
November	17,204	3,810	5,443	323,880	0.70	0.63
December	24,735	3,910	8,943	549,883	1.19	1.03
The Year	34,043	2,060	6,436	4,688,370	10.08	0.74

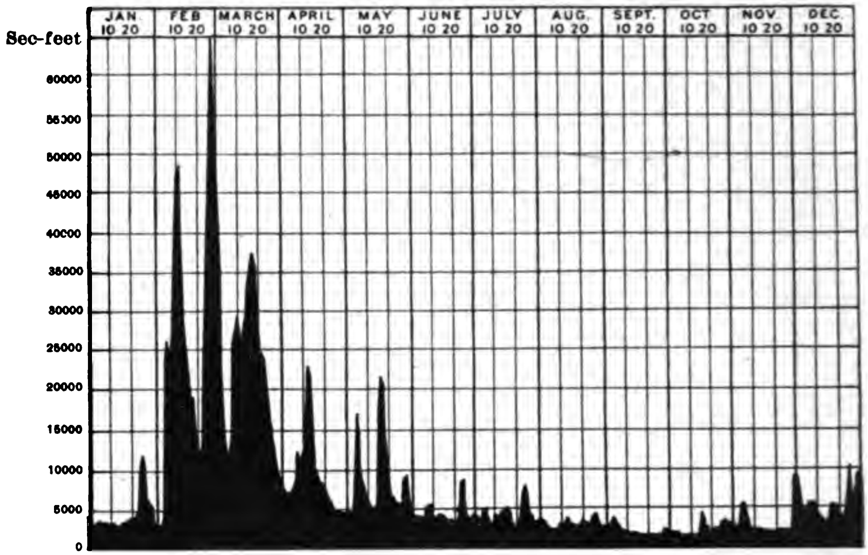

FIG. 19.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE ROANOKE RIVER, AT NEALS, N. C., FOR 1897. (U. S. G. S.)

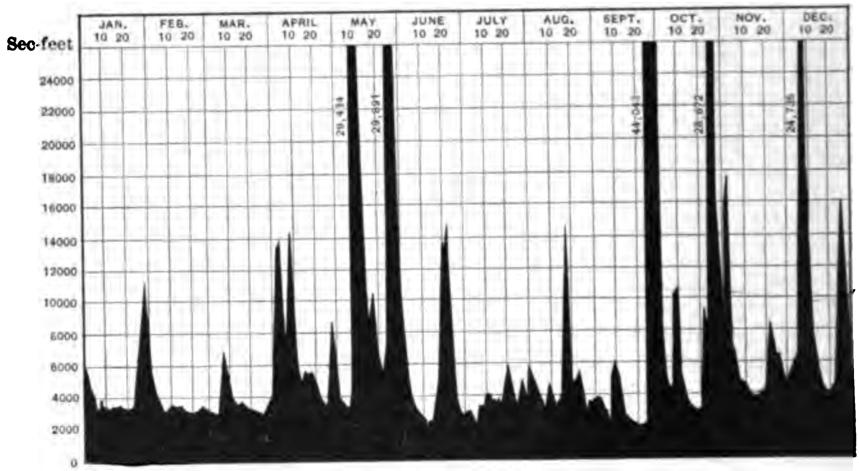

FIG. 20.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE ROANOKE RIVER, AT NEALS, N. C., FOR 1898.

TARBORO STATION ON THE TAR RIVER.

This station is in the town of Tarboro and is located on the bridge of the Atlantic Coast Line, which crosses the river here. This gauge was established July 25, 1896. The zero of the gauge-rod is over the center of the fifth floor beam from the east end of the bridge. The outer rim of the pulley-wheel is 3 feet from the zero of the gauge-rod, and the distance from the end of the weight to the pointer on the wire is 38.30 feet. The gauge-reading is zero when the weight touches the bottom of the stream. Measurements were taken here temporarily while the steel county bridge which crosses the river about one hundred yards above was under construction, and since that time have been made at the latter place. The section here is a good one, there being only one pier obstruction, caused by a steel tubular pier, 13 feet in diameter. The bottom is of sand and mud but seems to change very little.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON TAR RIVER AT TARBORO, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	July 25	E. W. Myers	2154	4.35	1,061	1.85	1,963
2	Sept. 5	....do	2154	0.43	225	1.67	376
3	Sept. 17	A. P. Davis	68	4.51	1,081	2.12	2,294
4	Dec. 17	E. W. Myers	2154	13.20	3,676	2.35	8,651
	1897.						
5	Jan. 23	E. W. Myers	2154	6.65	1,822	1.93	3,520
6	Feb. 26	....do	2154	13.58	3,489	2.32	8,106
7	Mar. 15	....do	2154	18.13	5,263	2.46	12,993
8	May 17	....do	2154	6.30	1,629	1.87	3,058
9	July 29	....do	2154	2.25	744	1.44	1,079
10	Oct. 2	....do	2154	—0.65	238	0.80	192
	1898.						
11	Jan. 13.	E. W. Myers	2154	2.30	877	1.51	1,323

RATING-TABLE FOR TAR RIVER AT TARBORO, NORTH CAROLINA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
0.00	280	4.00	1,880	8.00	4,400	12.00	7,260
0.20	324	4.20	2,000	8.20	4,540	12.20	7,420
0.40	368	4.40	2,120	8.40	4,680	12.40	7,580
0.60	412	4.60	2,240	8.60	4,820	12.60	7,740
0.80	456	4.80	2,360	8.80	4,960	12.80	7,920
1.00	500	5.00	2,480	9.00	5,100	13.00	8,100
1.20	560	5.20	2,600	9.20	5,240	13.20	8,280
1.40	630	5.40	2,720	9.40	5,380	13.40	8,460
1.60	710	5.60	2,840	9.60	5,520	13.60	8,640
1.80	790	5.80	2,970	9.80	5,660	14.00	9,000
2.00	870	6.00	3,100	10.00	5,800	14.50	9,460
2.20	950	6.20	3,220	10.20	5,940	15.00	9,960
2.40	1,035	6.40	3,340	10.40	6,080	15.50	10,440
2.60	1,120	6.60	3,460	10.60	6,220	16.00	10,940
2.80	1,220	6.80	3,580	10.80	6,360	16.50	11,420
3.00	1,320	7.00	3,710	11.00	6,500	17.00	11,920
3.20	1,420	7.20	3,840	11.20	6,640	17.50	12,400
3.40	1,530	7.40	3,980	11.40	6,780	18.00	12,900
3.60	1,640	7.60	4,120	11.60	6,940	.....	......
3.80	1,760	7.80	4,260	11.80	7 100	.....	......

ESTIMATED MONTHLY DISCHARGE OF TAR RIVER AT TARBORO, NORTH CAROLINA.

[Drainage area, 2290 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
July 26 to 31	1,618	774	1,268	15,090	0.13	0.55
August	1,574	390	628	38,614	0.31	0.27
September	3,910	302	1,190	70,809	0.58	0.52
October	2,000	408	703	43,226	0.35	0.30
November	1,910	476	842	50,102	0.41	0.37
December	9,460	1,420	3,739	229,904	1.88	1.63
					3.66	0.60

RATING-TABLE FOR TAR RIVER AT TARBORO, NORTH CAROLINA, FOR 1897-1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
—1.00	170	0.00	270	3.50	1,680	11.00	6,370
—0.90	177	0.20	310	4.00	1,935	12.00	7,180
—0.80	185	0.40	360	4.50	2,197	13.00	8,050
—0.70	192	0.60	410	5.00	2,460	14.00	8,950
—0.60	200	0.80	470	5.50	2,735	15.00	9,900
—0.50	210	1.00	540	6.00	3,015	16.00	10.900
—0.40	220	1.50	730	7.00	3,600	17.00	11,900
—0.30	230	2.00	960	8.00	4.250	18.00	12,900
—0.20	240	2.50	1,180	9.00	4,950	19.00	13,900
—0.10	255	3.00	1,430	10.00	5,650	20.00	14,900

ESTIMATED MONTHLY DISCHARGE OF TAR RIVER AT TARBORO, NORTH CAROLINA.

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	4,460	1,155	1,814	111,539	0.91	0.79
February	8,725	1,480	4,888	271,466	2.22	2.13
March	14,600	2,197	6,789	417,440	3.41	2.96
April	9,800	1,280	3,636	216,357	1.77	1.59
May	3,915	690	1,580	97,150	0.79	0.69
June	1,280	360	689	40,999	0.33	0.30
July	3,725	310	1,198	73,665	0.60	0.52
August	860	247	399	24,533	0.20	0.17
September	2,460	196	490	29,155	0.23	0.21
October	770	170	295	18,139	0.15	0.13
November	2,250	347	694	40,105	0.32	0.29
December	3,072	770	1,430	87,928	0.71	0.62
The year	14,600	170	1,990	1,428,476	11.64	0.87
1898.						
January	2,959	906	1,411	86,761	0.70	0.61
February	1,580	730	1,051	58,372	0.48	0.46
March	3,795	754	1,697	104,347	0.85	0.74
April	5,510	906	2,524	150,190	1.23	1.10
May	8,610	1,068	3.437	211,330	1.73	1.50
June	3,425	470	1,601	95,261	0.77	0.69
July	6,937	385	2,420	148,804	1.21	1.05
August	4,880	505	1,720	105,760	0.86	0.75
September	4,250	360	1,351	80,385	0.65	0.59
October	1,430	385	839	51,588	0.41	0.36
November	2,735	654	1,317	78,362	0.64	0.58
December	8,050	1,480	3,070	188,764	1.54	1.34
The year	8,610	360	1,870	1,357,924	11.07	0.81

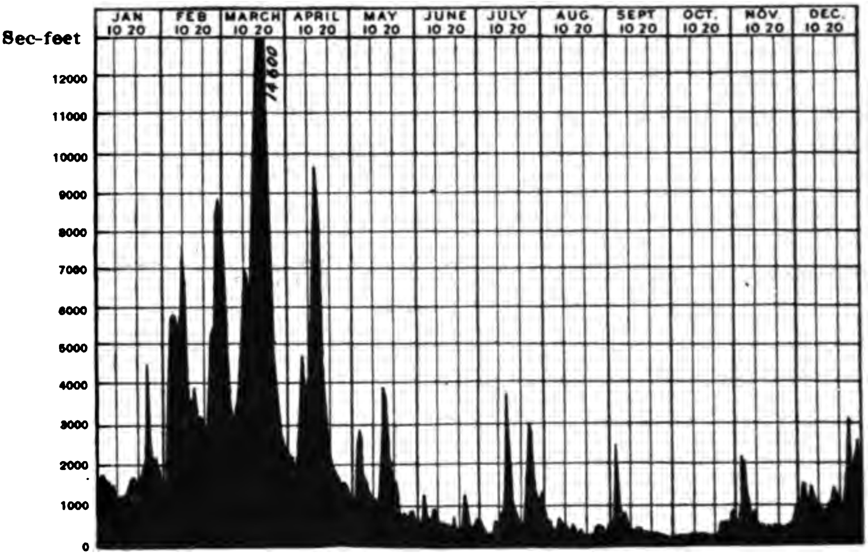

FIG. 21.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE TAR RIVER, AT TARBORO, N. C., FOR 1897. (U. S. G. S.)

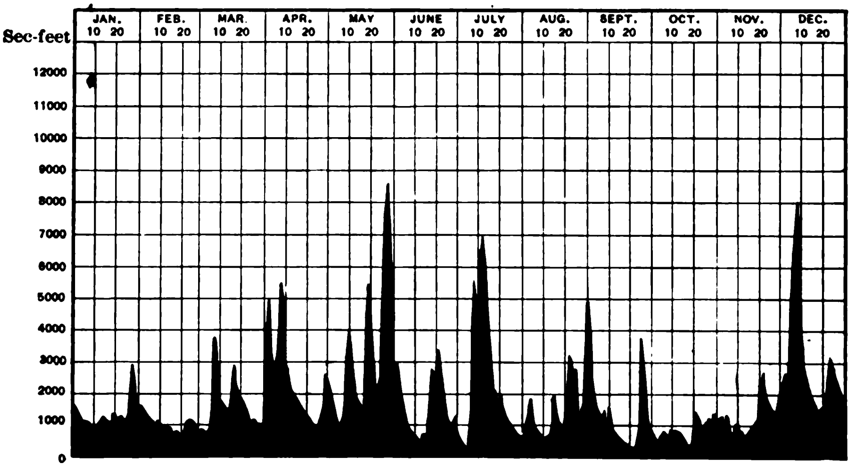

FIG. 22.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE TAR RIVER, AT TARBORO, N. C., FOR 1898.

SELMA STATION ON THE NEUSE RIVER.

This station is located on the Southern railroad bridge about three miles from Selma, and the gauge was put in on July 29, 1896. The zero of the gauge-rod is over the center of the fifth floor beam of the first span from the south end of the bridge. The distance from the zero of the gauge to the outer rim of the pulley is 4 feet, and the distance from the end of the weight to the pointer on the wire is 41.05 feet. The bed of the river here is of sand and is liable to change by high water. The course of the river is straight and there is only one pier obstruction.

A better section is found at the county bridge which crosses the river about three hundred yards below the railroad bridge, and it is here that the measurements are taken. The bottom here is harder and there are no pier obstructions.

The tables of daily gauge heights for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON NEUSE RIVER AT SELMA, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	July 29	E. W. Myers	2154	1.18	285	1.28	333
2	Sept. 5	....do	2154	0.80	215	0.94	203
3	Sept. 19	A. P. Davis	68	0.00	220	0.56	123
	1897.						
4	Jan. 24	E. W. Myers	2154	8.00	1,038	1.74	1,810
5	Feb. 23	....do	2154	10.60	1,842	2.19	4.052
6	Mar. 10	...do	2154	7.95	1,379	1.92	2,639
7	May 18	....do	2154	2.40	497	1.58	789
8	July 27	....do	2154	1.60	466	1.48	694
9	Oct. 1	....do	2154	−0.30	146	0.75	109
	1898.						
10	Jan. 9	E. W. Myers	2154	1.20	327	1.30	426
11	Aug. 31	....do	9	6.75	1,208	2.40	2,902
	1899.						
12	Feb. 6	....do	87	15.68	2,712	2.88	7,807

RATING-TABLE FOR NEUSE RIVER AT SELMA, NORTH CAROLINA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. Feet.
0.00	125	2.80	700	5.60	1.515	8.40	2,590
0.20	155	3.00	750	5.80	1,580	8.60	2,695
0.40	185	3.20	800	6.00	1.650	8.80	2,805
0.60	220	3.40	850	6.20	1,720	9.00	2,920
0.80	260	3.60	900	6.40	1.790	9.20	3,040
1.00	300	3.80	960	6.60	1,860	9.40	3,160
1.20	340	4.00	1,020	6.80	1.930	9.60	3,280
1.40	380	4.20	1,080	7.00	2,000	9.80	3,400
1.60	420	4.40	1,140	7.20	2,080	10.00	3,540
1.80	460	4.60	1,200	7.40	2.160	10.20	3,690
2.00	500	4.80	1.260	7.60	2,240	10.40	3,855
2.20	550	5.00	1.325	7.80	2.320	10.60	4.050
2.40	600	5.20	1,390	8.00	2,400	10.80	4,230
2.60	650	5.40	1,450	8.20	2,490	11.00	4,410

ESTIMATED MONTHLY DISCHARGE OF NEUSE RIVER AT SELMA, NORTH CAROLINA.

[Drainage area, 1175 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
August	1,480	170	448	27,239	0.44	0.38
September	1.337	125	213	12,674	0.20	0.18
October	2.080	140	315	19,369	0.31	0.27
November	1.260	185	321	19.101	0.30	0.27
December	2,920	340	874	53,741	0.85	0.74
					2.10	0.36

RATING-TABLE FOR NEUSE RIVER AT SELMA, NORTH CAROLINA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Sec. feet.	Feet.
—0.5	70	2.2	698	5.6	1,700	10.5	3,950
—0.4	75	2.4	754	5.8	1,760	11.0	4,260
—0.3	92	2.6	810	6.0	1,830	11.5	4,570
—0.2	110	2.8	866	6.2	1,900	12.0	4,880
—0.1	127	3.0	922	6.4	1,970	12.5	5,190
0.0	145	3.2	980	6.6	2,040	13.0	5,500
0.1	165	3.4	1,040	6.8	2,110	13.5	5,810
0.2	185	3.6	1,100	7.0	2,190	14.0	6,120
0.4	230	3.8	1,160	7.2	2,270	14.5	6,430
0.6	275	4.0	1,220	7.4	2,350	15.0	6,740
0.8	325	4.2	1,280	7.6	2,430	15.5	7,050
1.0	375	4.4	1,340	7.8	2,510	16.0	7,360
1.2	425	4.6	1,400	8.0	2,590	16.5	7,670
1.4	475	4.8	1,460	8.5	2,825	17.0	7,980
1.6	530	5.0	1,520	9.0	3,075	....	.....
1.8	586	5.2	1,580	9.5	3,355	....	.....
2.0	642	5.4	1,640	10.0	3,650	....	.....

ESTIMATED MONTHLY DISCHARGE OF NEUSE RIVER AT SELMA, NORTH CAROLINA.
[Drainage area 1175 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	3,243	400	846	52,020	0.83	0.72
February	5,624	558	2,302	177,846	2.04	1.96
March	7,856	810	2,903	128,500	2.85	2.47
April	6,430	586	811	48,258	0.77	0.69
May	2,975	475	920	56,570	0.90	0.78
June	1,830	252	570	33,920	0.54	0.48
July	1,700	230	658	40,460	0.64	0.56
August	586	165	232	14,265	0.23	0.20
September	185	92	145	8,627	0.13	0.12
October	230	75	126	7,747	0.13	0.11
November	726	145	265	15,768	0.26	0.23
December	1,830	375	795	48,882	0.78	0.68
The year	7,856	75	881	632,863	10.10	.075

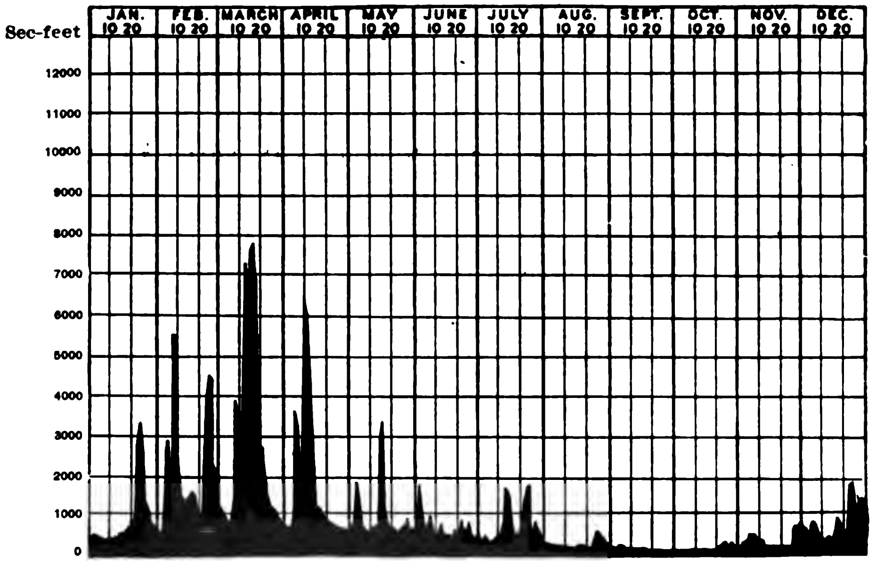

FIG. 23.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE NEUSE RIVER, AT SELMA, N. C., FOR 1897. (U. S. G. S.)

RATING-TABLE FOR NEUSE RIVER AT SELMA, NORTH CAROLINA, FOR 1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
0.00	145	2.30	732	5.20	2,066	9.80	4,590
0.10	165	2.40	762	5.40	2,172	10.00	4,700
0.20	185	2.50	792	5.60	2,280	10.20	4,810
0.30	207	2.60	822	5.80	2,390	10.40	4,920
0.40	230	2.70	855	6.00	2,500	10.60	5,030
0.50	252	2.80	890	6.20	2,610	10.80	5,140
0.60	275	2.90	930	6.40	2,720	11.00	5,250
0.70	300	3.00	972	6.60	2,830	11.20	5,360
0.80	325	3.10	1,017	6.80	2,940	11.40	5,470
0.90	350	3.20	1,062	7.00	3,050	11.60	5,580
1.00	375	3.30	1,110	7.20	3,160	11.80	5,690
1.10	400	3.40	1,160	7.40	3,270	12.00	5,800
1.20	425	3.50	1,210	7.60	3,380	12.50	6,075
1.30	450	3.60	1,260	7.80	3,490	13.00	6,350
1.40	475	3.70	1,310	8.00	3,600	13.50	6,625
1.50	502	3.80	1,360	8.20	3,710	14.00	6,900
1.60	530	3.90	1,410	8.40	3,820	14.50	7,175
1.70	558	4.00	1,460	8.60	3,930	15.00	7,450
1.80	586	4.20	1,560	8.80	4,040	15.50	7,725
1.90	614	4.40	1,660	9.00	4,150	16.00	8,000
2.00	642	4.60	1,760	9.20	4,260	.....	....
2.10	672	4.80	1,860	9.40	4,370	.....	....
2.20	702	5.00	1,960	9.60	4,480	.....	....

ESTIMATED MONTHLY DISCHARGE OF NEUSE RIVER AT SELMA, NORTH CAROLINA.

[Drainage area 1175 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	3,050	350	661	40,644	0.64	0.56
February	792	325	429	20,271	0.37	0.36
March	4,150	375	1,151	70,775	1.13	0.98
April	5,470	400	1,618	95,975	1.53	1.37
May	5,250	275	1,798	110,557	1.76	1.53
June	1,960	230	557	33,144	0.53	0.47
July	3,050	252	926	56,938	0.90	0.78
August	4,920	252	1,314	80,797	1.29	1.12
September	6,350	325	1,385	82,409	1.32	1.18
October	822	185	421	25,886	0.41	0.36
November	2,390	425	857	50,995	0.81	0.73
December	5,470	475	1.300	79,937	1.28	1.11
The year	6,350	185	1,034	748,328	11.97	0.88

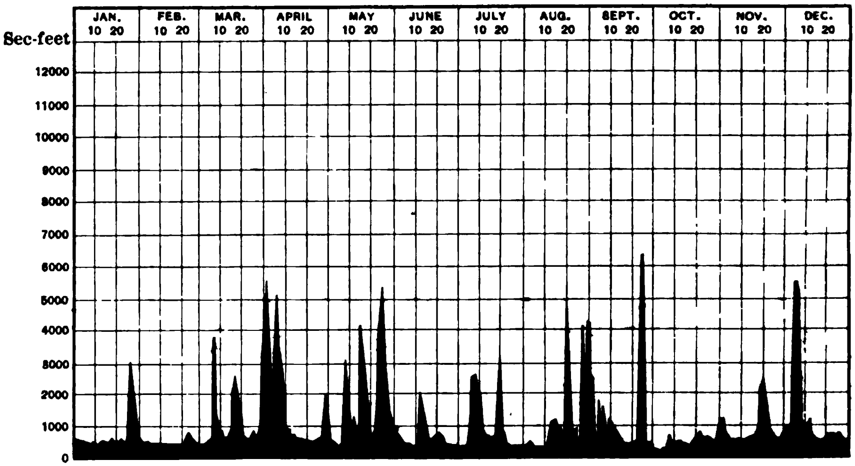

FIG. 24.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE NEUSE RIVER, NEAR SELMA, N. C., FOR 1898.

MONCURE STATION ON THE DEEP RIVER.

This station is located about one-fourth of a mile south of Moncure, Chatham county, North Carolina, at the covered wooden bridge of the Seaboard Air Line which crosses the river here, and about two miles above the junction with the Haw river to form the Cape Fear.

This station was established May 5, 1898. The name of the observer is M. A. Moore, Moncure, Chatham county, N. C., a farmer and also bridge watchman, living about one hundred yards from the bridge.

The gauge is a horizontal rod, well painted, divided into feet and tenths and securely nailed to the guard-rail of the bridge.

The zero of the rod is 50 feet south of the north end of the second span of the bridge from the north. The outer rim of the pulley-wheel is 3.7 feet from the zero of the rod, and from the end of the weight to the pointer on the wire rope is 45.16 feet, the gauge reading zero when the weight touches the bottom of the river.

The initial point for soundings is a notch cut in the guard-rail opposite the south end of the bridge and on the down-stream side.

The channel is straight for some distance above and below the station. The current velocity is not great but sufficient for the purpose, and is well distributed across the stream. Both banks are rather low and subject to overflow.

The bed of the river is of fine sand and mud and is probably subject to change in high water.

MONCURE STATION ON THE HAW RIVER.

This station is located about one and three-fourths miles north of Moncure, Chatham county, North Carolina, at the bridge of the Seaboard Air Line which crosses the river here, and about two miles above the junction with the Deep river to form the Cape Fear.

The station was established May 6, 1898. The name of the observer is M. A. Moore, Moncure, Chatham county, N. C.

The gauge is a horizontal rod, well painted, divided into feet and tenths and securely nailed to the outer side of the guard-rail of the bridge on the up-stream side. The two-foot mark on the rod is over the center of the second floor beam from the south end of the second span from the south end of the bridge. The outer rim of the pulley-wheel is 0.3 foot from the zero of the gauge-rod and the distance from the end of the weight to the pointer on the wire rope is 43.45 feet, the gauge reading zero when the weight touches the bottom of the stream.

The initial point for soundings is a notch cut in the guard-rail opposite the south end of the bridge and on the up-stream side, the section on this side being better than that on the down-stream side.

The channel is straight for some distance above and below the station. The current velocity is good and uniformly distributed across the stream. Both banks are rather low and somewhat subject to overflow in time of flood. The bed of the stream is of coarse sand and gravel and is probably not subject to any decided change in high water. The current here is somewhat modified by a fish dam about 150 yards above the bridge.

The station is reached by private conveyance from Moncure.

FAYETTEVILLE STATION ON THE CAPE FEAR RIVER.

In the summer of 1895 an examination was made of the river, and a station for measuring the flow was established at Fayetteville. The Weather Bureau has a substantial gauge fastened to the lower side of the east abutment of the covered highway bridge, this being about 400 feet above the railroad bridge from which discharge measurements are made. For the lower 29 feet this gauge consists of a rod divided into tenths and firmly fastened to the abutment. Above the 29-foot mark, a scale is painted on the rock.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON CAPE FEAR RIVER AT FAYETTEVILLE, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second feet).
	1895.						
1	Sept. 26	C. C. Babb	....	1.59	....	....	489
2	Dec. 7	....do	....	2.90	....	....	1,109
	1896.						
3	Apr. 5	E. W. Myers	21	19.80	4,868	2.16	10,525
4	Apr. 25	....do	21	4.00	932	1.73	1,618
5	May 23	....do	21	4.00	1,270	1.04	1,322
6	June 8	....do	21	10.00	2,901	1.73	5.041
7	June 8	... do	21	9.20	2,446	1.72	4,207
8	July 11	....do	21	49.10	22,852	2.24	51,115
9	Sept. 2	.. do	2154	1.10	400	1.29	519
10	Sept. 19	A. P. Davis	68	1.88	517	1.50	770
	1897.						
11	Mar. 12	E. W. Myers	2154	23.00	7,110	2.36	16,777
12	July 27	....do	2154	7.00	1,701	1.57	2,672
13	Sept. 30	....do	2154	0.70	327	1.29	424
	1898.						
14	Jan. 10	E. W. Myers	2154	3.55	758	1.72	1,303
15	Aug. 22	....do	9	28.85	9,132	2.54	23.215

RATING-TABLE FOR CAPE FEAR RIVER AT FAYETTEVILLE, NORTH CAROLINA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
1.00	489	7.20	3,334	13.40	6,913	22.00	14,287
1.20	550	7.40	3,442	13.60	7,033	23.00	15,646
1.40	612	7.60	3,550	13.80	7,153	24.00	17,005
1.60	678	7.80	3,658	14.00	7,273	25.00	18,364
1.80	744	8.00	3,766	14.20	7,393	26.00	19,723
2.00	810	8.20	3,878	14.40	7,513	27.00	21,082
2.20	876	8.40	3,990	14.60	7,633	28.00	22,441
2.40	942	8.60	4,102	14.80	7,753	29.00	23,800
2.60	1,008	8.80	4,214	15.00	7,873	30.00	25,159
2.80	1,075	9.00	4,326	15.20	7,993	31.00	26,458
3.00	1,145	9.20	4,438	15.40	8,113	32.00	27,877
3.20	1,229	9.40	4,550	15.60	8,233	33.00	29,236
3.40	1,319	9.60	4,672	15.80	8,355	34.00	30,595
3.60	1,417	9.80	4,784	16.00	8,479	35.00	31,954
3.80	1,517	10.00	4,898	16.20	8,603	36.00	33,313
4.00	1,620	10.20	5,013	16.40	8,727	37.00	34,627
4.20	1,728	10.40	5,129	16.60	8,851	38.00	36,031
4.40	1,836	10.60	5,245	16.80	8,975	39.00	37,390
4.60	1,940	10.80	5,361	17.00	9,099	40.00	38,749
4.80	2,048	11.00	5,477	17.20	9,223	41.00	40,108
5.00	2,156	11.20	5,598	17.40	9,347	42.00	41,467
5.20	2,264	11.40	5,713	17.60	9,471	43.00	42,826
5.40	2,372	11.60	5,833	17.80	9,595	44.00	44,185
5.60	2,470	11.80	5,953	18.00	9,719	45.00	45,554
5.80	2,578	12.00	6,073	18.20	9,843	46.00	46,903
6.00	2,686	12.20	6,193	18.40	9,967	47.00	48,262
6.20	2,794	12.40	6,313	18.60	10,091	48.00	49,621
6.40	2,902	12.60	6,433	18.80	10,215	49.00	50,980
6.60	3,010	12.80	6,553	19.00	10,339	50.00	52,339
6.80	3,118	13.00	6,673	20.00	11,569	.....	......
7.00	3,226	13.20	6,793	21.00	12,928	.....	......

ESTIMATED MONTHLY DISCHARGE OF CAPE FEAR RIVER AT FAYETTEVILLE, NORTH CAROLINA.

[Drainage area, 4,493 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
October	810	399	608	37,369	0.16	0.14
November	4,270	1,075	1,833	109,071	0.46	0.41
December	10,029	1,008	2,737	168,292	0.70	0.61
1896.						
January[1]	19,723	1,620	6,468	246,387	1.07	1.44
February[2]	49,621	2,956	10,190	586,129	2.47	2.29
March	5,477	2,318	3,501	215,269	0.91	0.789
April[2]	14,967	1,367	3,087	183,676	0.77	0.689
May	9,347	843	2,686	165,260	0.69	0.598
June[2]	11,569	1,041	3,492	207,774	0.81	0.777
July[2]	52,340	1,319	7,303	449,061	1.87	1.625
August	7,093	612	1,081	66,471	0.28	0.240
September	4,616	489	1,240	73,780	0.30	0.275
October[2]	26,458	843	2,623	161,278	0.67	0.583
November[2]	10,954	975	2,399	142,740	0.59	0.534
December	8,113	1,940	4,158	255,667	1.06	0.92
Per annum (1896)	52,340	489	4,019	2,753,492	11.49	0.897

[1] Twenty days in January.

[2] Maximum approximate.

RATING-TABLE FOR CAPE FEAR RIVER AT FAYETTEVILLE, NORTH CAROLINA, FOR 1897-'98.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. Feet.	Feet.	Sec. feet.
0.0	300	5.8	2,400	11.8	5,780	21.0	13,400
0.1	320	6.0	2,500	12.0	5,900	22.0	14,500
0.2	340	6.2	2,600	12.2	6,020	23.0	15,650
0.4	380	6.4	2,700	12.4	6,140	24.0	16,940
0.6	430	6.6	2,800	12.6	6,260	25.0	18,300
0.8	480	6.8	2,900	12.8	6,380	26.0	19,660
1.0	530	7.0	3,000	13.0	6,500	27.0	21,020
1.2	580	7.2	3,100	13.2	6,640	28.0	22,380
1.4	630	7.4	3,200	13.4	6,780	29.0	23,740
1.6	690	7.6	3,300	13.6	6,920	30.0	25,100
1.8	750	7.8	3,400	13.8	7,060	31.0	26,460
2.0	810	8.0	3,500	14.0	7,200	32.0	27,820
2.2	875	8.2	3,620	14.2	7,340	33.0	29,180
2.4	945	8.4	3,740	14.4	7,480	34.0	30,540
2.6	1,020	8.6	3,860	14.6	7,620	35.0	31,900
2.8	1,100	8.8	3,980	14.8	7,760	36.0	33,260
3.0	1,180	9.0	4,100	15.0	7,900	37.0	34,620
3.2	1,260	9.2	4,220	15.2	8,040	38.0	35,980
3.4	1,340	9.4	4,340	15.4	8,180	39.0	37,240
3.6	1,420	9.6	4,460	15.6	8,320	40.0	38,600
3.8	1,500	9.8	4,580	15.8	8,460	41.0	39,960
4.0	1,580	10.0	4,700	16.0	8,600	42.0	41,320
4.2	1,670	10.2	4,820	16.5	9,000	43.0	42,680
4.4	1,760	10.4	4,940	17.0	9,400	44.0	44,040
4.6	1,850	10.6	5,060	17.5	9,850	45.0	45,400
4.8	1,940	10.8	5,180	18.0	10,300	46.0	46,760
5.0	2,030	11.0	5,300	18.5	10,800	47.0	48,120
5.2	2,120	11.2	5,420	19.0	11,300	48.0	49,480
5.4	2,210	11.4	5,540	19.5	11,800	49.0	50,840
5.6	2,300	11.6	5,660	20.0	12,300	50.0	52,300

ESTIMATED MONTHLY DISCHARGE OF CAPE FEAR RIVER AT FAYETTEVILLE, NORTH CAROLINA.

[Drainage area, 4,493 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	17,688	1,580	3,694	227,140	0.94	0.82
February	33,688	2,255	12,802	710,986	2.97	2.85
March	35,708	3,100	12,233	752,280	3.14	2.72
April	22,788	1,760	6,871	408,850	1.71	1.53
May	9,760	1,580	3,191	196,210	0.82	0.71
June	3,860	750	1,833	109,070	0.46	0.41
July	18,708	780	3,180	195,530	0.82	0.71
August	2,900	875	1,570	96,535	0.40	0.35
September	1,850	360	664	39,510	0.17	0.15
October	875	340	517	31,790	0.14	0.12
November	4,520	630	1,281	76,230	0.32	0.29
December	4,700	1,180	2,165	133,120	0.55	0.48
The year	35,708	340	4,167	2,977,251	12.44	0.93
1898.						
January	7,273	1,273	2,071	127,555	0.53	0.46
February	2,686	1,109	1,757	97,584	0.41	0.39
March	12,257	1,229	3,252	200,291	0.83	0.72
April	13,616	1,567	4,342	258,349	1.07	0.96
May	8,665	1,145	2,505	154,016	0.64	0.56
June	3,226	519	1,163	69,203	0.29	0.26
July	8,665	489	2,858	175,736	0.72	0.63
August	23,972	942	5,632	346,300	1.44	1.25
September	10,277	876	3,674	218 615	0.91	0.82
October	4,955	612	1,745	107,296	0.45	0.39
November	7,333	1,417	2,975	177,027	0.73	0.66
December	9,781	1,904	3,887	208,255	0.86	0.75
The year	23,972	489	2.947	2.140.229	8.88	0.65

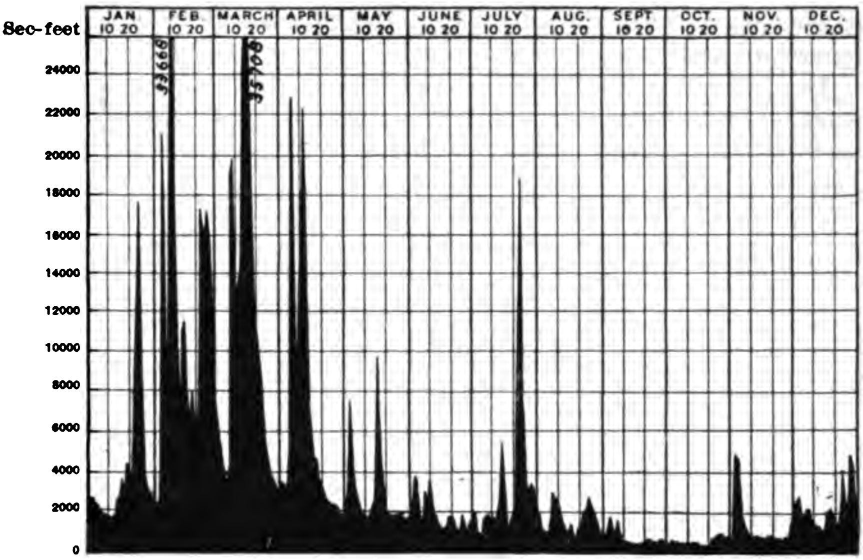

FIG. 25.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CAPE FEAR RIVER, AT FAYETTEVILLE, N. C., FOR 1897. (U. S. G. S.)

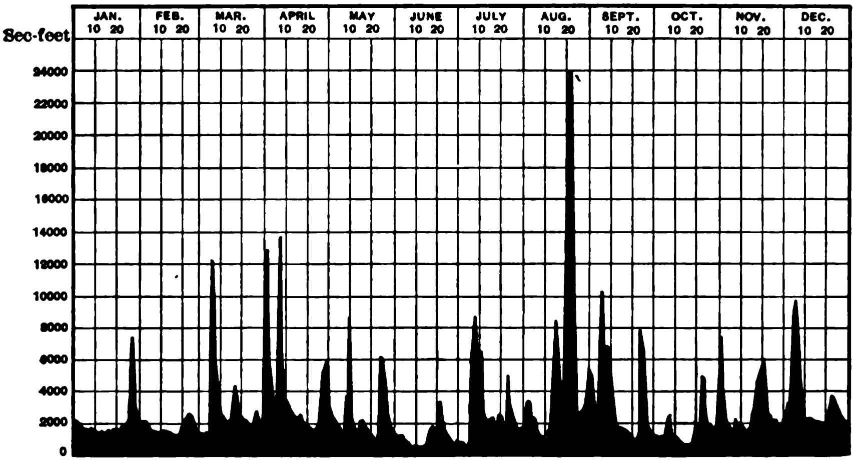

FIG. 26.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CAPE FEAR RIVER, AT FAYETTEVILLE, N. C., FOR 1898.

SALISBURY STATION ON THE YADKIN RIVER.

The upper point of measurement for the Yadkin river is at the Southern railway bridge near Salisbury. The section here is favorable. A gauge was located here on September 24, 1895. The 10-foot mark on the rod is opposite the centre of the sixth floor beam on the lower side of the first span from the west end. The distance from the zero of the rod to the outer rim of the pulley-wheel is 1.85 feet. The length of the wire rope and the weight is 55.10 feet. The locality is reached by private conveyance from Salisbury.

This river is known as the Yadkin for about thirty miles below this point, or down to the mouth of the Uharie river, entering from the north in Montgomery county. Below this point it is known as the Pee-Dee.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON YADKIN RIVER AT SALISBURY, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Oct. 5	C. C. Babb	29	1.44	1,190	1.22	1,457
2	Oct. 26	....do	76	1.45	1,159	1.33	1,538
3	Dec. 10	....do	62	1.74	1,534	1.57	2,415
	1896.						
4	Apr. 20	E. W. Myers	21	2.00	1,558	1.87	2,916
5	Aug. 29	....do	2154	1.50	1,318	0.98	1,298
6	Sept. 14	....do	21	1.79	1,486	1.66	2,368
	1897.						
7	Feb. 18	E. W. Myers	2154	4.20	2,997	3.38	10,141
8	Mar. 20	....do	2154	4.45	3,436	3.44	11,837
9	Apr. 18	....do	2154	3.90	3,223	3.10	9,992
10	Aug. 4	....do	2154	2.18	1,768	1.93	3,422
11	Oct. 6	....do	2154	1.40	1,018	1.28	1,300
	1898.						
12	Jan. 17	E. W. Myers	2154	2.10	1,412	1.81	2,567
13	Apr. 1	....do	2154	3.90	2,700	3.37	9,110
14	Aug. 18	....do	2154	5.00	3,328	3.38	11,237
	1899.						
15	Feb. 9	...do	87	6.50	3,851	3.83	14,781

RATING-TABLE FOR YADKIN RIVER AT SALISBURY, NORTH CAROLINA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.00	500	2.00	3,000	3.00	6,400	4.00	9,800
1.10	650	2.10	3,340	3.10	6,740	4.10	10,160
1.20	850	2.20	3,680	3.20	7,080	4.20	10,540
1.30	1,050	2.30	4,020	3.30	7,420	4.30	10,940
1.40	1,275	2.40	4,360	3.40	7,760	4.40	11,390
1.50	1,500	2.50	4,700	3.50	8,100	4.50	11,840
1.60	1,740	2.60	5,040	3.60	8,440	4.60	12,290
1.70	1,980	2.70	5,380	3.70	8,780	4.70	12,740
1.80	2,320	2.80	5,720	3.80	9,120	4.80	13,200
1.90	2,660	2.90	6,060	3.90	9,460	4.90	13,700

ESTIMATED MONTHLY DISCHARGE OF YADKIN RIVER AT SALISBURY, NORTH CAROLINA.
[Drainage area, 3,399 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
October	1,500	1,400	1,426	87,681	0.48	0.42
November	4,020	1,310	2,004	119,246	0.65	0.59
December	10,160	1,640	2,683	164,971	0.91	0.79
1896.						
January	10,940	1,640	4,485	275,774	1.52	1.32
February	[1]24,200	2,320	7,817	449,638	2.48	2.30
March	5,380	2,320	3,472	213,485	1.18	1.02
April	[1]29,200	2,660	5,242	311,920	1.72	1.54
May	6,060	1,310	2,507	154,149	0.85	0.74
June	9,460	1,310	3,159	187,974	1.03	0.93
July	[1]64,200	1,640	11,584	712,277	3.94	3.41
August	6,060	1,000	2,411	148,248	0.82	0.71
September	[1]32,200	1,000	3,087	183,689	1.01	0.91
October	[1]31,200	1,310	3,122	191,965	1.06	0.92
November	[1]23,200	1,980	5,206	309,779	1.65	1.48
December	[1]22,700	3,000	6,037	371,202	2.05	1.78
Per annum (1896)	[1]64,200	1,000	4,844	3,510,100	19.31	1.42

RATING-TABLE FOR THE YADKIN RIVER AT SALISBURY, NORTH CAROLINA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.0	560	3.2	7,116	5.4	14,860	7.6	22,604
1.2	900	3.4	7.820	5.6	15,564	7.8	23.308
1.4	1,310	3.6	8,524	5.8	16,268	8.0	24,012
1.6	1,760	3.8	9,228	6.0	16,972	8.5	25,772
1.8	2,300	4.0	9.932	6.2	17,676	9.0	27,532
2.0	2,920	4.2	10,636	6.4	18,380	9.5	29,292
2.2	3,596	4.4	11,340	6.6	19,084	10.0	31,052
2.4	4,300	4.6	12,044	6.8	19,788	10.5	32,812
2.6	5.004	4.8	12,748	7.0	20,492	11.0	34,572
2.8	5,708	5.0	13.452	7.2	21.196	11.5	36,332
3.0	6,412	5.2	14,156	7.4	21,900	....	......

ESTIMATED MONTHLY DISCHARGE OF THE YADKIN RIVER AT SALISBURY, NORTH CAROLINA.
[Drainage area, 3,399 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	12,044	2,600	4,039	248,350	1.37	1.19
February	34.924	4,652	11,597	644,065	3.45	3.41
March	25,068	4.652	10,522	646,970	3.58	3.10
April	31,756	3,948	7,761	461,810	2.54	2.28
May	14.156	3,250	5,776	355,150	1.96	1.70
June	19,788	2,300	5,652	336,320	1.85	1.66
July	11,692	2.600	4,821	296,430	1.64	1.42
August	5,708	1,760	2,943	180,960	1.00	0.87
September	3,250	900	1,785	106,215	0.59	0.53
October	25,772	900	3,557	218,600	1.21	1.05
November	7,116	900	2,708	161,140	0.89	0.80
December	5,708	2,300	3,086	189,750	1.05	0.91
The year	34,924	900	5,354	3,845,760	21.13	1.58

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[1] Estimated.

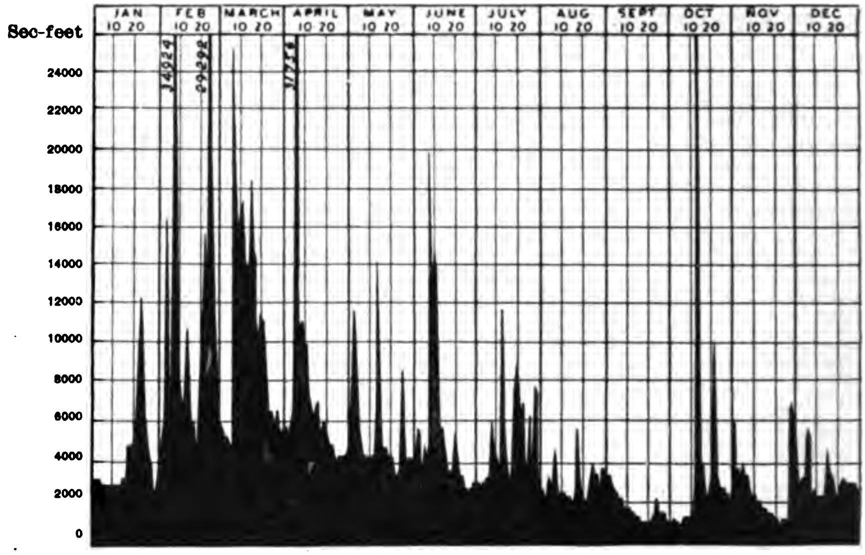

FIG. 27.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE YADKIN RIVER, AT SALISBURY, N. C., FOR 1897. (U. S. G. S.)

RATING-TABLE FOR YADKIN RIVER AT SALISBURY, NORTH CAROLINA, FOR 1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.20	1,000	3.20	6,350	5.50	12,410	10.50	42,115
1.40	1,250	3.40	7,150	6.00	13,585	11.00	46,520
1.60	1,550	3.60	8,000	6.50	14,780	11.50	50,925
1.80	1,900	3.80	8,850	7.00	15,980	12.00	55,330
2.00	2,325	4.00	9,290	7.50	18,830	12.50	59,735
2.20	2,850	4.20	9,675	8.00	21,700	13.00	64,140
2.40	3,450	4.40	10,065	8.50	25,300	13.50	68,545
2.60	4,100	4.60	10,450	9.00	28,900	14.00	72,950
2.80	4,800	4.80	10,840	9.50	33,305	14.50	77,355
3.00	5,550	5.00	11,235	10.00	37,710	15.00	81,760

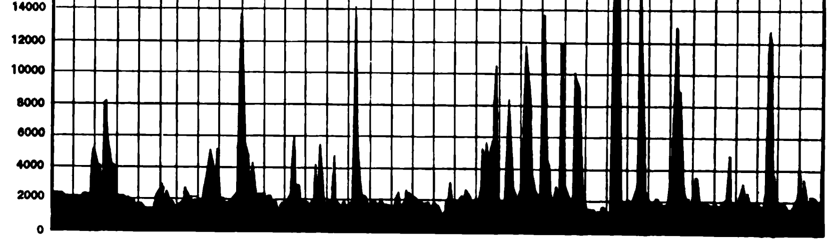

FIG. 28.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE YADKIN RIVER NEAR SALISBURY, N. C., FOR 1898.

ESTIMATED MONTHLY DISCHARGE OF THE YADKIN RIVER AT SALISBURY, NORTH CAROLINA.

[Drainage area 3,399 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	9,290	2,100	3,341	205,427	1.13	0.98
February	2,850	1,400	1,950	108,300	0.60	0.58
March	13,820	1,725	3,039	186,858	1.02	0.89
April	10,645	1,550	2,965	176,432	0.97	0.87
May	14,230	1,400	2,982	183,361	1.00	0.87
June	2,567	1,550	1,832	109,007	0.60	0.54
July	10,450	1,100	3,167	194,728	1.07	0.93
August	13,820	1,725	4,993	307,007	1.35	1.17
September	79,998	1,400	8,295	493,584	2.81	2.44
October	16,550	1,725	4,246	261,076	1.44	1.25
November	4,800	1,725	2,197	130,732	0.69	0.62
December	12,645	1,550	3,284	201,923	1.10	0.96
The year	79,998	1,100	3,524	2,558,435	13.78	1.01

NORWOOD STATION ON THE YADKIN RIVER.

This gauge was established September 1, 1896, at Blalock's ferry, about two miles from Norwood, N. C. The gauge is a vertical rod securely spiked and braced to an overhanging tree near the ferry, and is divided into feet and tenths. The rod is referred to a bench mark, consisting of a large nail driven into a notch cut in the root of a birch tree about 50 feet northwest of the rod, and the tree is immediately in front of the turn of the road leading to the ferry. The zero of the gauge is 5.93 feet below the elevation of the bench mark. The river here is about 960 feet wide, shallow, with a bottom of sand and small rocks, not subject to change by high water, and giving a good section for gauging. The measurements are taken from the ferry-boat.

The tables of daily gauge height for this station will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON YADKIN RIVER NEAR NORWOOD, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	Sept. 1	E. W. Myers	2154	1.00	1,859	0.82	1,537
2	Sept. 15	....do	2154	1.34	2,211	0.92	2,036
	1897.						
3	Feb. 12	E. W. Myers	2154	3.32	3,779	2.54	9,607
4	Mar. 21	....do	2154	3.80	4,517	2.59	11,710
5	Aug. 4	....do	2154	1.65	2,544	1.33	3,392
6	Oct. 6	....do	2154	1.00	1,821	0.82	1,508
7	Oct. 25	A. P. Davis	94	1.48	2,152	1.26	2,715
	1898.						
8	Jan. 16	E. W. Myers	2154	1.63	2,474	1.22	3,041
9	May 1	....do	2154	5.75	6,465	3.84	24,825

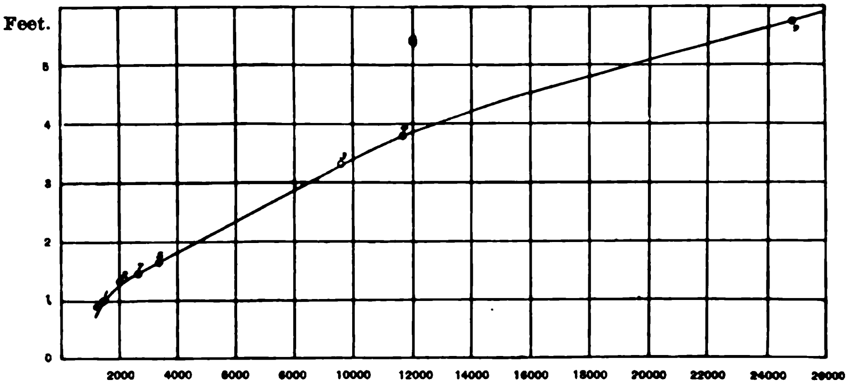

FIG. 29.—RATING CURVE FOR NORWOOD STATION, ON THE YADKIN RIVER, N. C.

RATING-TABLE FOR YADKIN RIVER AT NORWOOD, NORTH CAROLINA, FOR 1896.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
0.70	1,300	1.60	3,100	2.50	6,565	3.40	10,100
0.80	1,370	1.70	3,485	2.60	6,950	3.50	10,500
0.90	1,450	1.80	3,870	2.70	7,335	3.60	10,900
1.00	1,540	1.90	4,255	2.80	7,720	3.70	11,300
1.10	1,640	2.00	4,640	2.90	8,110	3.80	11,700
1.20	1,830	2.10	5,025	3.00	8,500	3.90	12,100
1.30	2,080	2.20	5,410	3.10	8,900	4.00	12,500
1.40	2,380	2.30	5,795	3.20	9,300	....	......
1.50	2,720	2.40	6,180	3.30	9,700	....	......

RATING-TABLE FOR YADKIN RIVER AT NORWOOD, NORTH CAROLINA FOR 1897-98.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
0.7	1,250	2.6	6,960	4.8	18,000	7.0	34,060
0.8	1,310	2.8	7,720	5.0	19,460	7.2	35,520
0.9	1,380	3.0	8,480	5.2	20,920	7.4	36,980
1.0	1,480	3.2	9,240	5.4	22,380	7.6	38,440
1.2	1,820	3.4	10,000	5.6	23,840	7.8	39,900
1.4	2,400	3.6	10,860	5.8	25,300	8.0	41,360
1.6	3,160	3.8	11,800	6.0	26,760	8.2	42,820
1.8	3,920	4.0	12,800	6.2	28,220	8.4	44,280
2.0	4,680	4.2	13,800	6.4	29,680	8.6	45,740
2.2	5.440	4.4	15,100	6.6	31,140	8.8	47,200
2.4	6 200	4.6	16.540	6.8	32.600	9.0	48,660

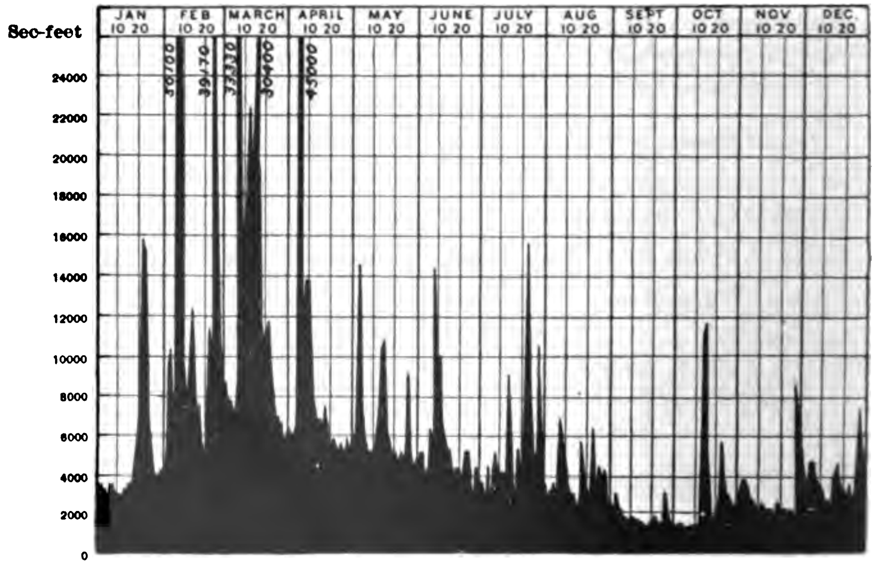

FIG. 30.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE YADKIN RIVER, AT NORWOOD, N. C., FOR 1897. (U. S. G. S.)

ESTIMATED MONTHLY DISCHARGE OF YADKIN RIVER AT NORWOOD, NORTH CAROLINA.

[Drainage area, 4,614 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
September	9,700	1,450	2,409	143,344	0.58	0.52
October	26,100	1,640	3,225	198,297	0.81	0.70
November	20,500	2,080	4,176	248,489	1.01	0.91
December	11,700	2,080	4,885	300,369	1.22	1.06
1897.						0.80
January	15,810	2,780	4,880	300,060	1.22	1.06
February	50,120	4,300	13,760	764,190	3.10	2.98
March	33,330	5,440	13,017	800,385	3.25	2.82
April	45,010	5,060	9,755	580,465	2.35	2.11
May	14,400	4,300	6,388	392,785	1.59	1.38
June	14,400	3,160	5,397	321,145	1.31	1.17
July	15,810	2,400	5,495	337,875	1.37	1.19
August	6,580	2,400	3,712	228,240	0.93	0.81
September	2,780	1,310	1,774	105,560	0.43	0.38
October	26,900	1,480	2,999	184,400	0.75	0.65
November	8,480	1,820	2,973	176,910	0.71	0.64
December	7,340	2,080	4,171	256,465	1.04	0.90
The year	50,120	1,310	6,193	4,448,480	18.05	1.34
1898.						
January	11,300	2,720	4,429	272,782	1.10	0.96
February	4,255	2,720	3,390	188,280	0.76	0.73
March	26,900	2,720	5,886	362,519	1.48	1.28
April	15,100	3,485	6,004	357,238	1.47	1.32
May	16,950	2,380	4,536	279,372	1.13	0.98
June	5,795	1,830	2,626	155,258	0.63	0.57
July	8,480	1,380	3,819	234,818	0.95	0.83
August	12,800	1,820	5,329	327,669	1.33	1.15
September	64,660	1,820	8,645	514,410	2.09	1.87
October	23,840	3,160	7,229	444,491	1.80	1.56
November	9,240	3,540	5,858	348,574	1.42	1.27
December	17,270	3,540	7,435	457,157	1.86	1.61
The year	64,660	1,380	5,432	3,942,568	16.02	1.18

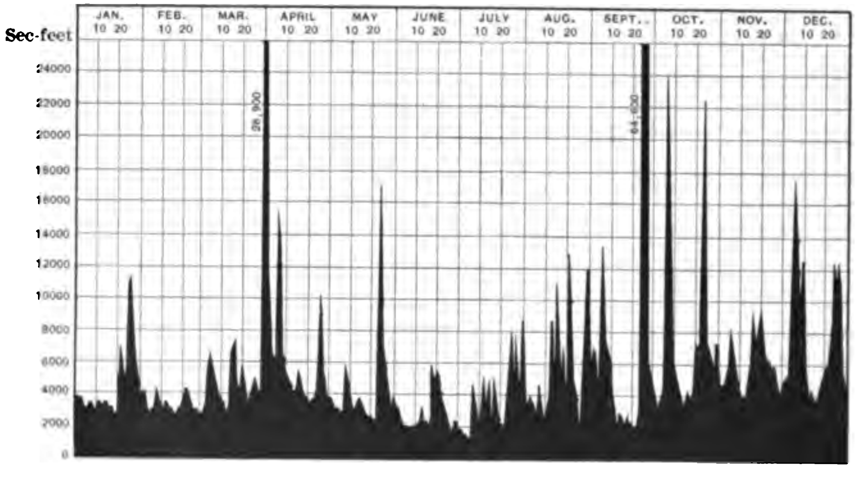

FIG. 31.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE YADKIN RIVER, AT NORWOOD, N. C., FOR 1898.

CATAWBA STATION ON THE CATAWBA RIVER.

This, the upper point at which measurements of discharge are made on this river, is located about one-fourth of a mile from the town of Catawba, on the Southern railway bridge that crosses the river at this point. The zero of the gauge-rod is 23 feet east of the west end of the second span of the bridge, and the distance from the zero of the gauge to the outer rim of the pulley-wheel is 3 feet. The distance from the end of the weight to the marker on the wire is 35.58 feet, the reading being zero when the weight touches the bottom of the stream. The section here is a fairly good one as the bottom is smooth, but of sand or clay and seemingly liable to change by high water. The river is straight for several hundred yards above and below the station and the current velocity is fairly uniform all the way across. The section is somewhat obstructed by a sand-bank on the east side of the river a little up-stream from the station, which throws most of the water to the west bank, and the water near the east bank is shallow.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON CATAWBA RIVER AT CATAWBA, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	June 30	E. W. Myers	21	2.25	938	1.11	1,044
2	July 4	....do	21	3.03	1,238	1.83	2,266
3	Aug. 30	....do	2154	1.45	748	0.98	732
4	Sept. 13	....do	2154	1.94	1,059	1.37	1,458
	1897.						
5	Feb. 8	E. W. Myers	2154	5.52	2,915	3.33	9,711
6	Aug. 3	....do	2154	1.90	975	1.39	1,358
7	Oct. 5	....do	2154	1.60	825	0.93	775
8	Oct. 26	A. P. Davis	94	1.82	1,098	1.16	1,279
	1898.						
9	Jan. 14	E. W. Myers	2154	2.01	1,072	1.14	1,228

RATING-TABLE FOR CATAWBA RIVER AT CATAWBA, NORTH CAROLINA, FOR 1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.00	540	2.50	1,630	4.00	5,000	5.50	9,500
1.10	570	2.60	1,740	4.10	5,300	5.60	9,800
1.20	610	2.70	1,860	4.20	5,600	5.70	10,100
1.30	655	2.80	1,990	4.30	5,900	5.80	10,400
1.40	710	2.90	2,140	4.40	6,200	5.90	10,700
1.50	770	3.00	2,300	4.50	6,500	6.00	11,000
1.60	835	3.10	2,480	4.60	6,800	6.10	11,300
1.70	910	3.20	2,700	4.70	7,100	6.20	11,600
1.80	980	3.30	2,950	4.80	7,400	6.30	11,900
1.90	1,060	3.40	3,220	4.90	7,700	6.40	12,200
2.00	1,140	3.50	3,500	5.00	8,000	6.50	12,500
2.10	1,230	3.60	3,800	5.10	8,300	6.60	12,800
2.20	1,320	3.70	4,100	5.20	8,600	6.70	13,100
2.30	1,420	3.80	4,400	5.30	8,900	6.80	13,400
2.40	1,530	3.90	4,700	5.40	9,200	6.90	13,700

ESTIMATED MONTHLY DISCHARGE OF CATAWBA RIVER AT CATAWBA, NORTH CAROLINA.

[Drainage area, 1535 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
July 4 to 31	16,100	1,420	4,466	248,024	3.35	2.91
August	1,420	770	1,071	65,858	0.79	0.69
September	5,000	770	1,090	64,859	0.79	0.71
October	1,630	770	865	53,187	0.64	0.56
November	15,200	835	2,222	132,218	1.62	1.45
December	9,800	1,060	2,149	132,137	1.61	1.40
					8.80	1.29

RATING-TABLE FOR CATAWBA RIVER AT CATAWBA, NORTH CAROLINA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.5	750	3.8	4,535	6.6	12,795	10.0	22,825
1.6	850	4.0	5,125	6.8	13,385	10.5	24,300
1.7	950	4.2	5,715	7.0	13,975	11.0	25,775
1.8	1,050	4.4	6,305	7.2	14,565	11.5	27,250
1.9	1,160	4.6	6,895	7.4	15,155	12.0	28,725
2.0	1,270	4.8	7,485	7.6	15,745	12.5	30,200
2.2	1,490	5.0	8,075	7.8	16,335	13.0	31,675
2.4	1,730	5.2	8,665	8.0	16,925	13.5	33,150
2.6	1,980	5.4	9,255	8.2	17,515	14.0	34,625
2.8	2,250	5.6	9,845	8.4	18,105	14.5	36,100
3.0	2,560	5.8	10,435	8.6	18,695	15.0	37,575
3.2	2,980	6.0	11,025	8.8	19,285	15.5	39,050
3.4	3,450	6.2	11,615	9.0	19,875	16.0	40,525
3.6	3,960	6.4	12,205	9.5	21,350	....	......

ESTIMATED MONTHLY DISCHARGE OF CATAWBA RIVER AT CATAWBA, NORTH CAROLINA.

[Drainage area, 1535 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	6,452	1,050	1,647	101,270	1.23	1.07
February	40,230	1,550	7,006	389,095	4.79	4.60
March	17,663	1,550	5,637	346,605	4.24	3.67
April	40,525	2,180	5,014	298,355	3.64	3.26
May	11,025	1,435	2,600	159,870	1.95	1.69
June	3,450	1,270	1,833	109,070	1.33	1.19
July	3,210	1,270	1,774	109,080	1.34	1.16
August	2,560	950	1,321	81,225	0.99	0.86
September	1,380	900	1,017	60,515	0.73	0.66
October	16,925	850	1,787	109,880	1.35	1.17
November	2,560	950	1,233	73,370	0.89	0.80
December	1,850	1,105	1,328	81,656	0.99	0.86
The year	40,525	850	2,683	1,919,991	23.47	1.75

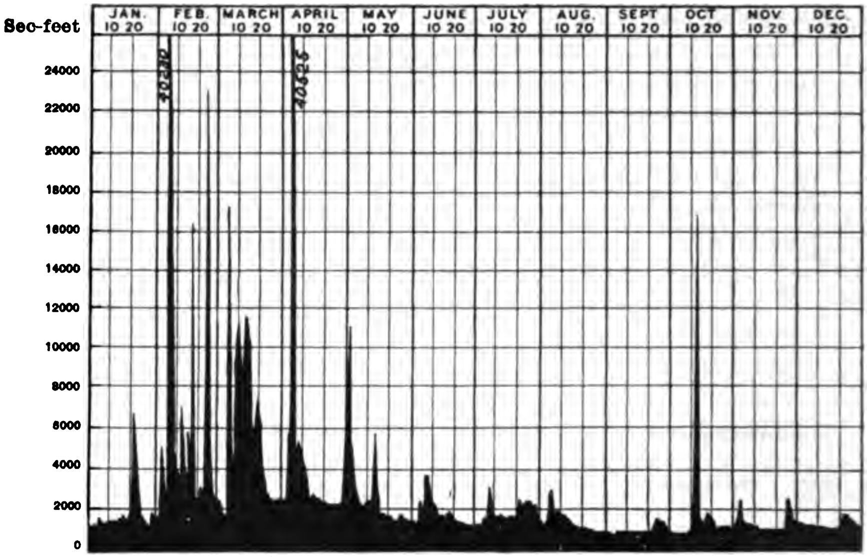

FIG. 32.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CATAWBA RIVER, AT CATAWBA, N. C., FOR 1897. (U. S. G. S.)

RATING-TABLE FOR CATAWBA RIVER AT CATAWBA, NORTH CAROLINA, FOR 1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.5	750	3.6	4,375	7.2	14,715	13.5	33,300
1.6	870	3.8	4,875	7.4	15,305	14.0	34,775
1.7	1,000	4.0	5,400	7.6	15,895	14.5	36,250
1.8	1,140	4.2	5,940	7.8	16,485	15.0	37,725
1.9	1,280	4.4	6,495	8.0	17,075	15.5	39,200
2.0	1,425	4.6	7,065	8.2	17,665	16.0	40,675
2.1	1,575	4.8	7,640	8.4	18,255	16.5	42,150
2.2	1,725	5.0	8,225	8.6	18,845	17.0	43,650
2.3	1,875	5.2	8,815	8.8	19,435	17.5	45,150
2.4	2,025	5.4	9,405	9.0	20,025	18.0	46,650
2.5	2,175	5.6	9,995	9.5	21,500	18.5	48,150
2.6	2,325	5.8	10,585	10.0	22,975	19.0	49,650
2.7	2,500	6.0	11,175	10.5	24,450	19.5	51,150
2.8	2,675	6.2	11,765	11.0	25,925	20.0	52,650
2.9	2,860	6.4	12,355	11.5	27,400	20.5	54,150
3.0	3,050	6.6	12,945	12.0	28,875	21.0	55,650
3.2	3,450	6.8	13,535	12.5	30,350	21.5	57,150
3.4	3,900	7.0	14,125	13.0	31,825	22.0	58,650

ESTIMATED MONTHLY DISCHARGE OF CATAWBA RIVER AT CATAWBA, NORTH CAROLINA.

[Drainage area, 1535 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	9,500	1,100	1,710	105,145	1.28	1.11
February	1,320	1,100	1,172	65,092	0.79	0.76
March	15,500	1,060	1,983	121,932	1.49	1.29
April	2,950	1,230	1,493	88,835	1.07	0.96
May	3,500	1,020	1,276	78,461	0.95	0.83
June	3,500	910	1,069	63,605	0.77	0.69
July	14,125	1,140	3,292	202,415	2.47	2.14
August	21,990	1,425	5,018	308,556	3.76	3.26
September	52,500	1,500	6,667	396,709	4.85	4.35
October	27,400	2,675	7,202	442,831	5.40	4.69
November	3,675	2,325	2,689	159,917	1.95	1.75
December	9,995	2,175	3,162	194,421	2.37	2.06
The year	52,500	1,000	3,251	2,365,196	28.80	2.11

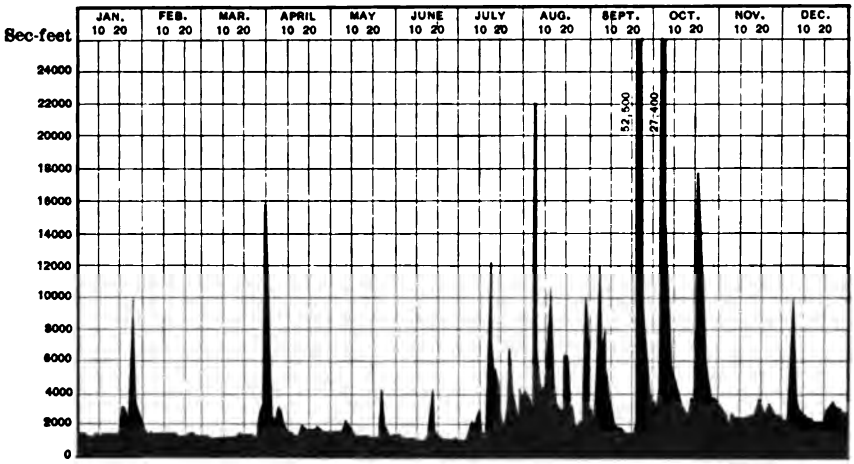

FIG. 33.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CATAWBA RIVER, AT CATAWBA, N. C., FOR 1898.

ROCK HILL STATION ON THE CATAWBA RIVER.

The Catawba river, a short distance south of the North Carolina state line, is crossed by three railroad bridges, these being in succession down stream, the bridge of the Southern railway, three miles south of Fort Mill, the bridge of the Seaboard Air Line (Georgia, Carolina and Northern) about three miles from Catawba Junction, and below this the bridge of the Ohio river and Charleston railroad. Each of these was examined to ascertain the most desirable point for making river measurements. It was decided that the highest of these crossings near Fort Mill was the most desirable, and a gauge was placed here on September 3, 1895. It is fastened to the upper side of the guard-rail, the two-foot mark of the rod being over the center of the second vertical of the second truss from the south end of the bridge. The distance from the zero of the rod to the outer rim of the pulley-wheel is 1.30 feet, and the length of the wire rope from the pointer on the wire to the end of the weight is 52.96 feet. The station is reached by private conveyance from Rock Hill, S. C.

Above this point observations of river height have been kept by the Weather Bureau at Mount Holly, N. C., this point being five miles north of the state line and nearly 25 miles from the Rock Hill station. A gauge here is attached to one of the piers, but readings have not been made since 1884. Measurements of discharge could not be satisfactorily made at this point, as the river is very sluggish just under the bridge, and is said to be ponded by a dam one mile below.

The tables of daily gauge height for this station will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON CATAWBA RIVER AT ROCK HILL, SOUTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Sept. 23	C. C. Babb	29	1.58	806	1.66	1,340
2	Oct. 25	....do	76	1.51	852	1.73	1,477
	1896.						
3	Apr. 16	E. W. Myers	21	1.90	1,159	1.54	1,787
4	Aug. 20	....do	2154	1.78	924	1.63	1,508
5	Sept. 17	....do	2154	1.53	979	1.36	1,336
	1897.						
6	Feb. 9	E. W. Myers	2154	4.50	3,178	3.05	9,711
7	Apr. 6	....do	76	12.10	10,121	4.54	46,040
8	Aug. 15	....do	2154	1.55	1,091	1.83	2,006
9	Oct. 8	....do	2154	1.21	896	1.71	1,532
10	Nov. 1	A. P. Davis	94	1.45	1,254	2.09	2,619
	1898.						
11	Jan. 26	E. W. Myers	2154	3.20	2,297	3.36	7,732
12	Oct. 26	....do	2154	3.50	2,033	3.49	7,108
	1899						
13	Feb. 23	...do	87	3.61	2,556	3.16	8,066

RATING-TABLE FOR CATAWBA RIVER AT ROCK HILL, SOUTH CAROLINA.

[This table is applicable from September, 1895, to December, 1896.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.	Feet.	Sec. feet.
1.20	1,140	4.20	8,720	7.20	21,900	10.20	36,500
1.40	1,260	4.40	9,340	7.40	22,800	10.40	37,500
1.60	1,400	4.60	10,150	7.60	23,700	10.60	38,500
1.80	1,550	4.80	11,050	7.80	24,600	10.80	39,500
2.00	1,900	5.00	12,000	8.00	25,500	11.00	40,500
2.20	2,520	5.20	12,900	8.20	26,500	11.20	41,500
2.40	3,140	5.40	13,800	8.40	27,500	11.40	42,500
2.60	3,760	5.60	14,700	8.60	28,500	11.60	43,500
2.80	4,380	5.80	15,600	8.80	29,500	11.80	44,500
3.00	5,000	6.00	16,500	9.00	30,500	12.00	45,500
3.20	5,620	6.20	17,400	9.20	31,500	12.20	46,500
3.40	6,240	6.40	18,300	9.40	32,500	12.40	47,500
3.60	6,860	6.60	19,200	9.60	33,500	12.60	48,500
3.80	7,480	6.80	20,100	9.80	34,500	12.80	49,500
4.00	8,100	7.00	21,000	10.00	35,500	13.00	50,500

ESTIMATED MONTHLY DISCHARGE OF CATAWBA RIVER NEAR ROCK HILL, SOUTH CAROLINA.

[Drainage area, 2,987 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
September 23 to 30	1,350	1,300	1,318	20,912	0.13	0.44
October	1,400	1,300	1,364	83,869	0.53	0.46
November 1 to 9, 17 to 30	2,237	1,400	1,546	70,518	0.44	0.52
December	6,860	1,400	2,192	134,782	0.84	0.73
1896.						
January	9,700	1,550	3,062	188,275	1.19	1.03
February	19,850	2,237	6,098	350,478	2.20	2.04
March	2,851	1,700	2,009	123,528	0.77	0.67
April	16,040	1,470	2,645	157,389	0.99	0.89
May	9,060	1,400	2,277	140,008	0.87	0.76
June	5,620	1,330	2,014	119,841	0.74	0.67
July	[1]62,500	1,400	10,215	628,095	3.95	3.42
August	1,930	1,330	1,604	98,626	0.62	0.54
September	9,060	1,330	1,873	111,451	0.70	0.63
October	7,790	1,330	1,670	102,684	0.64	0.56
November	14,120	1,400	2,661	158,340	0.99	0.89
December	14,600	1,550	3,169	194,855	1.22	1.06
Per annum (1896)	[1]62,500	1,330	3,274	2,373,565	14.88	1.10

[1] Estimated.

RATING-TABLE FOR CATAWBA RIVER NEAR ROCK HILL, SOUTH CAROLINA, FOR 1897.

Gauge height.	Discharge.		Gauge height.	Discharge.		Gauge height.	Disch'rge	Gauge height.	Disch'rge
	Jan. 1 to Feb. 6.	Feb. 7 to Dec. 31.		Jan. 1 to Feb. 6.	Feb. 7 to Dec. 31.		Feb. 7 to Dec. 31.		Feb. 7 to Dec. 31.
1.00	.....	1,600	2.40	2,700	3,450	5.00	9,800	9.00	25,500
1.20	.....	1,700	2.60	3,100	3,800	5.50	11,800	10.00	31,000
1.40	1,250	1,900	2.80	3,500	4,200	6.00	13,000	11.00	38,000
1.60	1,450	2,200	3.00	3,900	4,600	6.50	14,750	12.00	45,300
1.80	1,700	2,500	3.50	5,050	5,750	7.00	16,550	13.00	52,700
2.00	2,000	2,800	4.00	6,400	7,000	7.50	18,500	14.00	60,100
2.20	2,350	3,100	4.50	8,050	8,375	8.00	20,500	15.00	67,500

ESTIMATED MONTHLY DISCHARGE OF CATAWBA RIVER NEAR ROCK HILL, SOUTH CAROLINA.

[Drainage area, 2987 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	5,550	1,575	2,097	128,940	0.81	0.70
February	65,650	1,775	9,277	515,220	3.24	3.11
March	19,300	3,275	7,537	463,430	2.91	2.52
April	54,920	3,100	7,055	419,800	2.63	2.36
May	8,100	2,650	3,571	219,575	1.38	1.20
June	7,825	2,200	3,128	186,130	1.17	1.05
July	10,550	2,060	2,900	178,315	1.12	0.97
August	8,925	1,975	2,587	159,070	1.00	0.87
September	2,200	1,700	1,817	108,120	0.68	0.61
October	9,200	1,900	2,311	142,100	0.89	0.77
November	4,000	1,900	2,186	130,075	0.81	0.73
December	3,100	2,125	2,523	155,185	0.97	0.84
The year	65,650	1,575	3,916	2,806,120	17.61	1.31

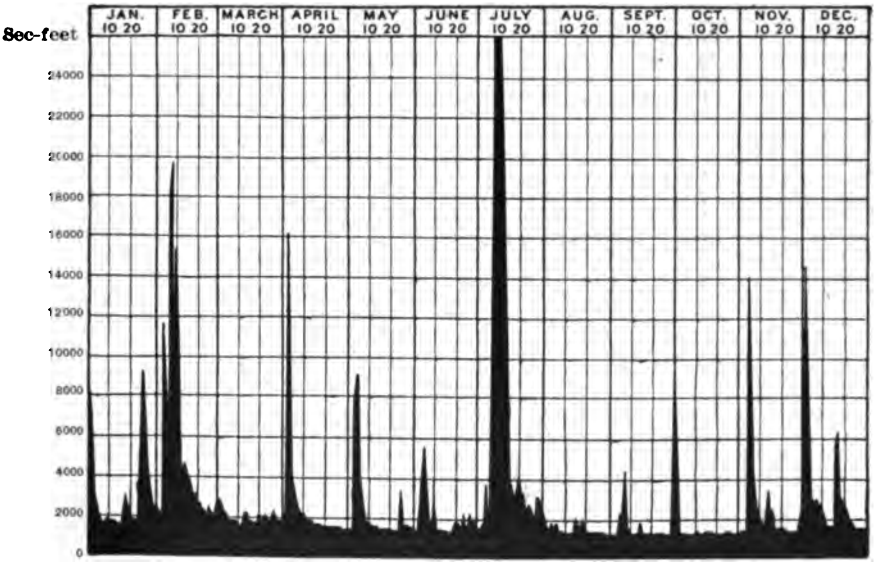

FIG. 34.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CATAWBA RIVER, AT ROCK HILL, S. C., FOR 1896. (U. S. G. S.)

RATING-TABLE FOR CATAWBA RIVER AT ROCK HILL, SOUTH CAROLINA, FOR 1898.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.0	1,800	2.5	5,000	5.0	12,400	9.5	32,500
1.1	1,950	2.6	5,270	5.2	13,120	10.0	35,000
1.2	2,100	2.7	5,540	5.4	13,840	10.5	37,500
1.3	2,260	2.8	5,810	5.6	14,560	11.0	40,000
1.4	2,430	2.9	6,080	5.8	15,280	11.5	42,750
1.5	2,610	3.0	6,350	6.0	16,000	12.0	45,500
1.6	2,810	3.2	6,930	6.2	16.800	12.5	49,550
1.7	3,020	3.4	7,510	6.4	17,600	13.0	53,600
1.8	3,240	3.6	8,100	6.6	18,400	13.5	57,700
1.9	3,460	3.8	8,700	6.8	19,200	14.0	61,800
2.0	3,700	4.0	9,300	7.0	20,000	14.5	65,900
2.1	3,960	4.2	9,900	7.5	22,500	15.0	70,000
2.2	4,220	4.4	10,500	8.0	25,000	15.5	74,100
2.3	4,480	4.6	11,120	8.5	27,500	16.0	78,200
2.4	4,740	4.8	11,760	9.0	30,000	...	.....

ESTIMATED MONTHLY DISCHARGE OF CATAWBA RIVER NEAR ROCK HILL, SOUTH CAROLINA.
[Drainage area, 2987 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	7,668	2,200	2,794	171,816	1.08	0.94
February	2,800	2,050	2,369	131,563	0.82	0.79
March	15,125	2,050	2,860	175,854	1.09	0.95
April	7,240	2,050	3,066	182,439	1.14	1.02
May	3,275	1,700	2,142	131,706	0.83	0.72
June	5,290	1,600	2,091	124,423	0.81	0.70
July	9,600	1,800	3,822	235,002	1.48	1.28
August	28,000	3,240	6,532	411,641	2.51	2.18
September[1]	6,930	3,460	6,042	71,899	0.45	2.02
October	36,500	4,480	10,498	641,214	4.05	3.51
November	7,800	5,000	5,594	332,865	2.09	1.87
December	12,080	4,480	6,186	380,367	2.38	2.07
The year	36,500	1,800	4,869	3,258,048	20.39	1.63

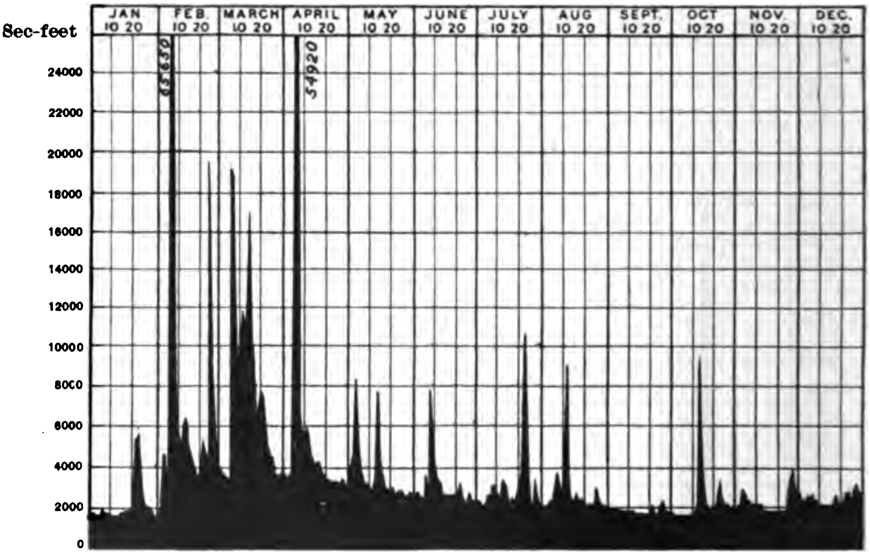

FIG. 35.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CATAWBA RIVER, AT ROCK HILL, S. C., FOR 1897. (U. S. G. S.)

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[1] 6 days' record.

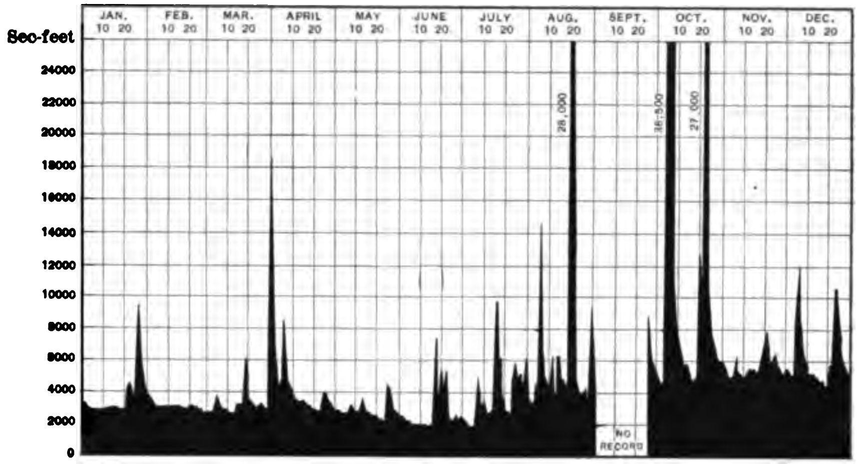

FIG. 36.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE CATAWBA RIVER, AT ROCK HILL, S. C., FOR 1898.

GAFFNEY STATION ON THE BROAD RIVER.

This gauge is located on the Southern railway bridge about three miles from Gaffney, S. C., and was established July 1, 1896. The zero of the gauge is 18 feet east of the west end of the third span of the bridge from the east. The distance from the zero of the gauge to the outer rim of the pulley-wheel is 2.5 feet, and from the end of the weight to the pointer on the wire is 50.71 feet. The section under the bridge is a good one, as the river is straight for several hundred yards above and below the bridge and the current velocity is uniformly distributed all the way across. The river here is broad and there are several pier obstructions. The measurements are therefore taken at a ferry about one-fourth of a mile above the bridge, where the river is much narrower. The measurements are taken from the ferry-boat. The section here is very good except that the bottom seems liable to cut out in high water.

This gauge was broken September 30, 1898, and when it was replaced it was moved to the ferry above where the gaugings have been made.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON BROAD RIVER NEAR GAFFNEY, SOUTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet.)	Area of section (square feet.)	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	Aug. 18	E. W. Myers	2154	0.26	732	1.36	956
2	Sept. 16	....do	2154	0.10	792	1.20	950
	1897.						
3	Mar. 9	E. W. Myers	2154	2.85	2,077	2.10	4,364
4	Apr. 7	....do	76	3.49	2,286	2.33	5,324
5	Aug. 6	....do	2154	1.64	1,201	1.08	1,297
6	Oct. 9	....do	2154	0.92	1,106	0.75	829
7	Oct. 31	A. P. Davis	94	1.38	1,190	0.72	861
	1898.						
8	Jan. 27	E. W. Myers	2154	2.67	1,784	1.71	3,052

RATING-TABLE FOR BROAD RIVER NEAR GAFFNEY, SOUTH CAROLINA.

[This table is applicable from July, 1896, to April 1897.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
0.00	800	1.10	1,910	2.20	3,305	3.30	5,010
0.10	885	1.20	2,035	2.30	3,450	3.40	5.170
0.20	975	1.30	2.160	2.40	3,600	3.50	5,330
0.30	1,075	1.40	2,285	2.50	3,750	3.60	5,500
0.40	1,175	1.50	2,410	2.60	3,900	3.70	5,670
0.50	1,275	1.60	2,535	2.70	4,050	3.80	5,840
0.60	1,375	1.70	2,660	2.80	4,210	3.90	6,010
0.70	1,475	1.80	2,785	2.90	4,370	4.00	6,180
0.80	1,575	1.90	2,910	3.00	4,530		.....
0.90	1,685	2.00	3.035	3.10	4,690		.....
1.00	1,795	2.10	3,170	3.20	4,850		.....

ESTIMATED MONTHLY DISCHARGE OF BROAD RIVER NEAR GAFFNEY, SOUTH CAROLINA.

[Drainage area, 1,435 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
July 12 to 31	2,585	1,255	1,496	59.340	0.77	1.04
August	1,445	885	1,093	67,206	0.87	0.76
September	2,585	843	1,119	66,585	0.87	0.78
October	1,585	980	1,086	66,776	0.87	0.76
November	3,800	1,055	1,955	116,331	1.52	1.36
December	3,945	1,545	1,977	121,561	1.59	1.38
					6.49	1.01

RATING-TABLE FOR BROAD RIVER NEAR GAFFNEY, SOUTH CAROLINA, FOR 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
0.7	780	2.6	3,504	4.6	8,264	6.6	13,024
0.8	790	2.8	3,980	4.8	8,740	6.8	13,500
0.9	810	3.0	4,456	5.0	9,216	7.0	13,976
1.0	845	3.2	4,932	5.2	9,692	7.5	15,166
1.2	940	3.4	5,408	5.4	10,168	8.0	16,356
1.4	1,070	3.6	5,884	5.6	10,644	8.5	17,546
1.6	1,250	3.8	6,360	5.8	11,120	9.0	18,736
1.8	1,600	4.0	6,836	6.0	11,596	...	......
2.0	2,076	4.2	7,312	6.2	12,072	...	......
2.4	3,028	4.4	7,788	6.4	12,548	...	......

ESTIMATED MONTHLY DISCHARGE OF BROAD RIVER NEAR GAFFNEY, SOUTH CAROLINA.
[Drainage area, 1435 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
January	2,790	800	1,026	63,090	0.82	0.71
February	18,022	970	4,111	228,315	2.99	2.87
March	11,596	1,719	4,556	280,140	3.67	3.18
April	18,736	1,957	4,198	249,800	3.26	2.93
May	7,550	4,694	5,402	332,155	4.34	2.76
June	10,287	3,623	5,126	305,020	3.98	3.57
July	7,074	2,076	4,310	265,010	3.46	3.00
August	3,861	1,070	1,951	119,960	1.57	1.36
September	1,600	790	929	55,280	0.72	0.65
October	7,312	790	1,244	76,490	1.00	0.87
November	3,266	845	1,264	75,215	0.98	0.88
December	3,266	940	1,521	93,520	1.22	1.06
The year	18,736	790	2,970	2,143,995	28.01	1.99

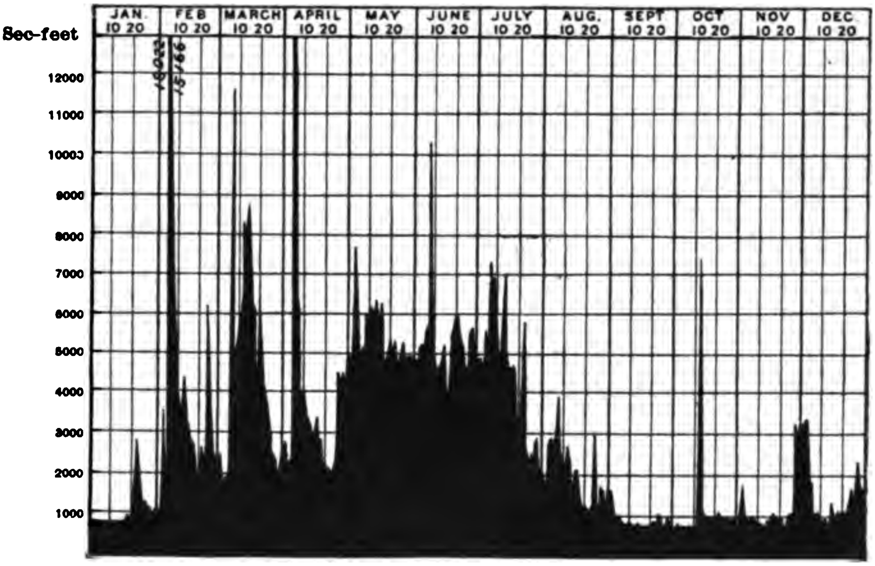

FIG. 37.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE BROAD RIVER, NEAR GAFFNEY, S. C., FOR 1897. (U. S. G. S.)

RATING-TABLE FOR BROAD RIVER NEAR GAFFNEY, SOUTH CAROLINA, FOR 1898.
[This table is applicable only from October 25, 1898, to December 31, 1898.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge Height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.6	1,350	2.2	2,000	3.2	3,510	4.2	6,250
1.7	1,450	2.4	2,250	3.4	3,950	4.4	7,050
1.8	1,550	2.6	2,550	3.6	4,450	....	....
1.9	1,650	2.8	2,850	3.8	4,975	....	....
2.0	1,750	3.0	3,150	4.0	5,550	....	....

Estimated Monthly Discharge of Broad river near Gaffney, South Carolina.

[Drainage area, 1485 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	4,242	802	1,396	85,765	1.12	0.97
February	3,599	863	1,477	82,031	1.07	1.08
March	5,941	871	1,311	80,610	1.05	0.91
April	3,966	994	1,744	103,775	1.35	1.21
May	1,205	869	1,011	62,164	0.82	0.71
June	1.338	769	864	51.411	0.67	0.60
July	4,542	782	1,394	85.715	1.04	0.90
August	6,337	890	1.721	105,822	1.37	1.19
September	21,306	985	3,707	220,579	2.88	2.58
October[1]	3,000	2,250	2,741	27,190	0.43	1.91
November	2.700	1,750	1,981	118,814	1.54	1.33
December	6,650	1,450	2,418	148,682	1.94	1.63
The year	21,306	769	1,814	1,172,558	15.28	1.25

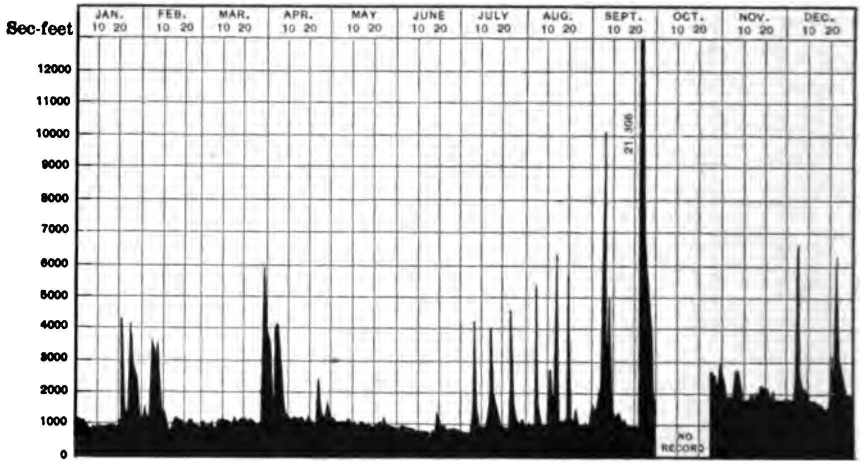

FIG. 38.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE BROAD RIVER NEAR GAFFNEY, S. C., FOR 1898.

ASHEVILLE STATION ON THE FRENCH BROAD RIVER.

The French Broad river rises in western North Carolina and flows northeasterly, crossing the state line into Tennessee, where it flows into the Tennessee river. An examination was made from about Asheville down to the state line to determine the best point to make continuous measurements of discharge. The principal points examined were at the bridges at Asheville, at Marshall, 22 miles below, and at Hot Springs, 16 miles further down.

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[1] Six days' record.

At Asheville four bridges cross the river. The uppermost of these is located just below the mouth of Swannanoa river, about 1.5 miles above the city. This locality would be desirable for making measurements, but for the fact that the current is ponded and modified on the south side by a log boom directly under the bridge. The river has a broad bend to the south above the bridge, tending to throw the greatest velocity toward the north shore during high water. This place can be reached from town by electric cars. The old three-span highway bridge, about one-fourth mile below the railway station, is at a poor section, the bottom being rough and uneven. The railroad four-pier bridge one-fourth of a mile below this is at a still poorer place, and crosses the river diagonally. The Bingham School bridge, 1.5 miles below the town, offers the best opportunity presented by any one of the four, although the bed of the river is rough and rocky. The bridge has three spans, each 91 feet in length. The two piers in the stream are cylindrical columns, two feet in diameter, and thus offer but little resistance to the current. It was therefore decided to locate a measuring station here after an inspection of the river as far down as Hot Springs. The zero of the gauge-rod here is opposite the east edge of the fifth upright of the first span from the east and on the upper side of the bridge. The outer rim of the pulley-wheel is 3 feet from the zero of the gauge-rod, and from the end of the weight to the pointer on the wire rope is 26.03 feet.

On September 3 Mr. Babb measured the French Broad at Hot Springs, N. C., 38 miles below Asheville, the water at that time being 22.80 feet below the top of the sixth iron support in the foot-rail on the lower side of the bridge, opposite the middle member of the first truss from the railroad side. The total discharge was ascertained to be 1359 second-feet. On the same day a measurement was made at Marshall, 16 miles above Hot Springs and 22 miles below Asheville. At that time the water surface was 19.69 feet below the upper end of the second floor beam of the second span from the north side. The discharge was computed to be 1490 second-feet. The section at this place is poor, the bottom rough, and it is not considered that the results obtained at this place are as accurate as those obtained at Hot Springs.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON FRENCH BROAD RIVER AT ASHEVILLE, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1895.						
1	Sept. 2	C. C. Babb.................	29	4.30	650	1.84	1,192
2	Sept. 17	....do	29	3.22	585	1.72	1,006
	1896.						
3	Apr. 18	E. W. Myers	21	2.90	533	1.22	650
4	June 19	....do.....................	21	3.42	685	2.18	1,495
5	Aug. 16	....do.....................	2154	3.25	543	2.00	1,089
6	Sept. 19	....do.....................	2154	2.50	438	1.58	694
	1897.						
7	Aug. 18	E. W. Myers	2154	2.86	531	1.65	882
8	Oct. 14	....do.....................	2154	2.84	469	1.72	806
9	Oct. 27	A. P. Davis................	94	2.50	434	1.69	734
	1898.						
10	Jan. 18	E. W. Myers	2154	2.75	502	1.82	918
11	Sept. 8	....do.....................	9	5.45	1,089	3.06	3,332

RATING-TABLE FOR FRENCH BROAD RIVER AT ASHEVILLE, NORTH CAROLINA.

Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
2.0	620	3.6	1,530	5.2	3,130	6.8	4,730
2.1	633	3.7	1,630	5.3	3,230	6.9	4,830
2.2	645	3.8	1,730	5.4	3,330	7.0	4,930
2.3	665	3.9	1,830	5.5	3,430	7.1	5,030
2.4	685	4.0	1,930	5.6	3,530	7.2	5,130
2.5	715	4.1	2,030	5.7	3,630	7.3	5,230
2.6	745	4.2	2,130	5.8	3,730	7.4	5,330
2.7	782	4.3	2,230	5.9	3,830	7.5	5,430
2.8	820	4.4	2,330	6.0	3,930	7.6	5,530
2.9	875	4.5	2,430	6.1	4,030	7.7	5,630
3.0	930	4.6	2,530	6.2	4,130	7.8	5,730
3.1	1,030	4.7	2,630	6.3	4,230	7.9	5,830
3.2	1,130	4.8	2,730	6.4	4,330	8.0	5,930
3.3	1,230	4.9	2,830	6.5	4,430	....	...
3.4	1,330	5.0	2,930	6.6	4,530	....	....
3.5	1,430	5.1	3,030	6.7	4,630	....	....

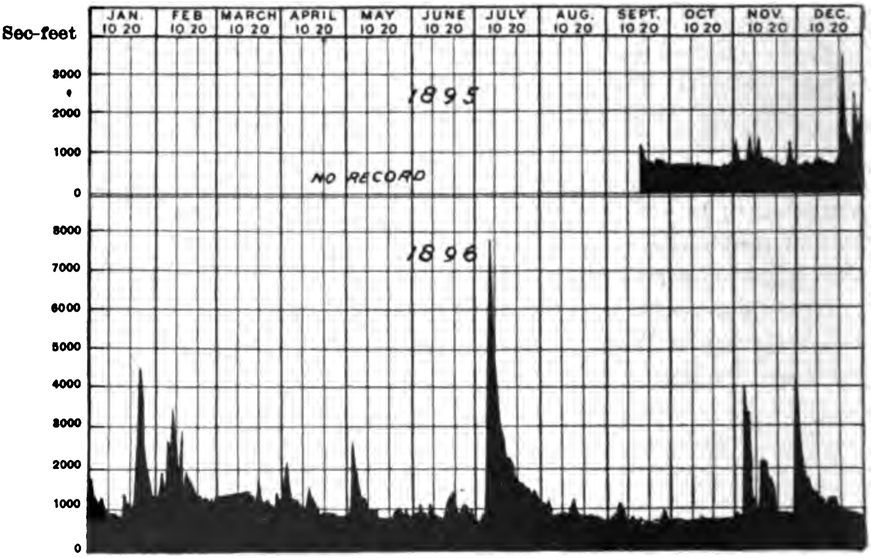

FIG. 39.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE FRENCH BROAD RIVER, AT ASHEVILLE, N. C., FOR 1895 AND 1896. (U. S. G. S.)

ESTIMATED MONTHLY DISCHARGE OF FRENCH BROAD RIVER AT ASHEVILLE, NORTH CAROLINA.

[Drainage area, 987 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1895.						
September 17-30	1,180	745	823	22,854	0.43	0.83
October	780	710	732	45,009	0.85	0.74
November	1,230	745	844	50,221	0.94	0.85
December	3,330	745	1,154	70,956	1.35	1.17
					3.57	0.89
1896.						
January	4,430	800	1,439	88,481	1.68	1.46
February	3,380	1,180	1,733	99,684	1.90	1.76
March	1,630	1,080	1,227	38,944	0.74	1.24
April	2,130	820	1,092	64,978	1.24	1.11
May	2,530	780	1,063	65,362	1.25	1.08
June	1,330	745	922	54,863	1.03	1.93
July	7,780	727	2,191	134,719	2.56	2.22
August	1,180	710	866	53,248	1.01	0.88
September	1,180	672	772	45,937	0.87	0.78
October	762	685	705	43,348	0.82	0.71
November	4,130	762	1,634	97.230	1.85	1.66
December	3,730	845	1,281	78,765	1.50	1.30
The year	7,780	672	1,244	865,759	16.45	1.26
1897.						
January	2,330	780	1,164	71.570	1.36	1.18
February	5,830	1,530	2,709	145,450	2.85	2.74
March	5,180	1.630	3,036	186,680	3.55	3.08
April	5,530	1,580	2,607	155,130	2.04	2.64
May	5,060	1,180	1,920	118,056	2.25	1.95
June	2,430	980	1,410	83,900	1.60	1.43
July	1,580	800	1,187	72,985	1.38	1.20
August	1,930	710	908	55,830	1.06	0.92
September	762	672	698	41,535	0.79	0.71
October	1,280	652	792	48,698	0.92	0.80
November	1,780	652	841	50,040	0.94	0.85
December	1,580	697	950	58,412	1.10	0.96
The year	5,830	652	1,518	1,088,284	20.75	1.54
1898.						
January	3,230	815	1,348	82,885	1.57	1.36
February	1,450	810	967	53,704	1.02	0.98
March	3,960	745	1,047	64,377	1.22	1.06
April	2,580	903	1.576	93,779	1.77	1.59
May	1,930	782	1,095	67,329	1.28	1.11
June	2,430	715	1,020	60,694	1.15	1.03
July	4,930	675	1,991	124,424	2.33	2.02
August	6,580	1.630	2,915	179,241	3.40	2.95
September	5,230	1.330	2,327	138,467	2.63	2.36
October	6,230	1,230	2,951	181,454	3.44	2.99
November	1,530	940	1,197	71,222	1.35	1.21
December	3,430	875	1,682	103 425	1.96	1.70
The year	6.580	675	1,676	1,221,001	23.12	1.70

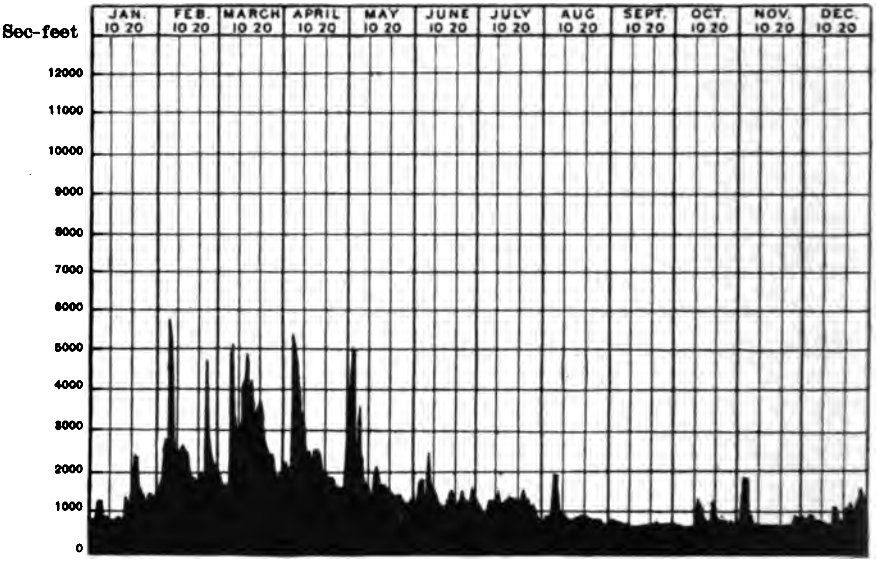

FIG. 40.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE FRENCH BROAD RIVER, AT ASHEVILLE, N. C., FOR 1897. (U. S. G. S.)

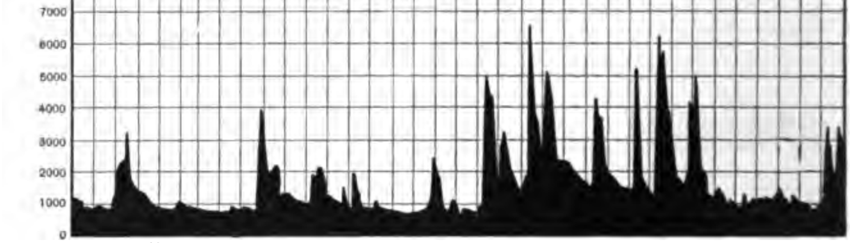

FIG. 41.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE FRENCH BROAD RIVER, AT ASHEVILLE, N. C., FOR 1898.

GOVERNOR'S ISLAND STATION ON THE TUCKASEEGEE RIVER (NOW BRYSON CITY STATION).

This station was located on the Southern railway bridge about three miles above Bryson City and just below Governor's Island P. O., and was established June 26, 1896. The zero of the gauge-rod was 20 feet from the end of the second span from the south end of the bridge. The outer rim of the pulley-wheel was one foot from the zero of the gauge-rod, and from the end of the weight to the pointer on the wire was 26.75 feet, the gauge reading zero when the weight touched bottom. The bottom is rocky and not subject to change, and the banks are high, but the section is not a good one as there are two bad pier obstructions and the bridge is across a bend in the river, the greater part of the current being thrown toward the west bank. The discharge measurements are not sufficiently comprehensive to justify the construction of a rating table for this station, which was abandoned March 25, 1897.

On November 7, 1897, a new station was established on the highway bridge across this river, in the town of Bryson City. The bottom here is muddy and the water sluggish. The gauge-rod is of wood, well painted and is spiked and bolted by drift bolts to the down-stream side of the north pier. The gauge is read from the bridge. The initial point for soundings is the south end, up-stream hand-rail. The observer is H. H. Welch.

LIST OF DISCHARGE MEASUREMENTS MADE ON THE TUCKASEEGEE AT BRYSON CITY, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1897						
1	Oct. 28	A. P. Davis................	94	1.00	518	0.33	168
	1898						
2	Jan. 19	E. W. Myers	2154	2.20	1217	1.78	2,175
3	Jan. 20	....do......................	2154	3.30	1396	2.64	3,695
4	Sept. 3	....do......................	9	6.95	2420	7.83	18,959
5	Sept. 4	....do......................	9	3.92	1843	3.40	6,059
6	Sept. 5	... do......................	9	5.00	1914	6.15	11,777
7	Sept. 5	....do......................	9	4.50	1615	5.56	9,086

RATING-TABLE FOR TUCKASEEGEE RIVER AT BRYSON CITY, NORTH CAROLINA.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
1.0	168	2.8	2,900	4·6	8,850	6.4	16,500
1.1	234	2.9	3,075	4.7	9,275	6.5	16,925
1.2	400	3.0	3,250	4.8	9,700	6.6	17,350
1.3	535	3.1	3,425	4.9	10,125	6.7	17,775
1.4	670	3.2	3,600	5.0	10,550	6.8	18,200
1.5	810	3.3	3,825	5.1	10,975	6.9	18,625
1.6	950	3.4	4,050	5.2	11,400	7.0	19,050
1.7	1,100	3.5	4,425	5.3	11,825	7.1	19,500
1.8	1,250	3.6	4,800	5.4	12,250	7.2	19,950
1.9	1,400	3.7	5,175	5.5	12,675	7.3	20,400
2.0	1,550	3.8	5,550	5.6	13,100	7.4	20,850
2.1	1,710	3.9	5,950	5.7	13,525	7.5	21,300
2.2	1,870	4.0	6,350	5.8	13,950	7.6	21,750
2.3	2,035	4.1	6,750	5.9	14,375	7.7	22,200
2.4	2,200	4.2	7,150	6.0	14,800	7.8	22,650
2.5	2,375	4.3	7,575	6.1	15,225	7.9	23,100
2.6	2,550	4.4	8,000	6.2	15,650	8.0	23,550
2.7	2,725	4.5	8,425	6.3	16,075		

LIST OF DISCHARGE MEASUREMENTS MADE ON TUCKASEEGEE RIVER, AT GOVERNOR'S ISLAND NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896						
1[1]	June 22	E. W. Myers	21	....	1100	0.81	892
2	June 26	....do...	21	2.26	272	3.08	821
3	Aug. 12	....do....	2154	2.42	207	3.90	809
4	Sept. 21	....do	2154	1.84	238	2.48	593

[1] Measurement made at Bryson City.

ESTIMATED DISCHARGE OF THE TUCKASEEGEE AT BRYSON CITY, NORTH CAROLINA.

[Drainage area, 629 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
November	670	168	240	14,280	0.43	0.38
December	4,050	284	941	51,860	1.73	1.50
1898.						
January	8,425	400	1,865	114,668	3.41	2.96
February	1,325	603	893	49,695	1.48	1.42
March	17,775	585	1,936	119,042	3.53	3.08
April	3,425	1,475	2,107	125,366	3.73	3.35
May	1,550	810	1.123	69,058	2.05	1.78
June	1,400	468	643	38,260	1.17	1.02
July	4,425	535	1,114	68,449	2.04	1.77
August	22,650	1,250	3,027	186,080	5.54	4.81
September	25,800	1,100	3,868	230,159	6.85	6.14
October	21,750	1,100	3,826	235,248	7.01	6.08
November	2,375	1,250	1,763	104,901	3.12	2.80
December	3,075	950	1,888	118,016	3.36	2.92
The year	25,800	643	2,000	1,458,887	43.29	3.17

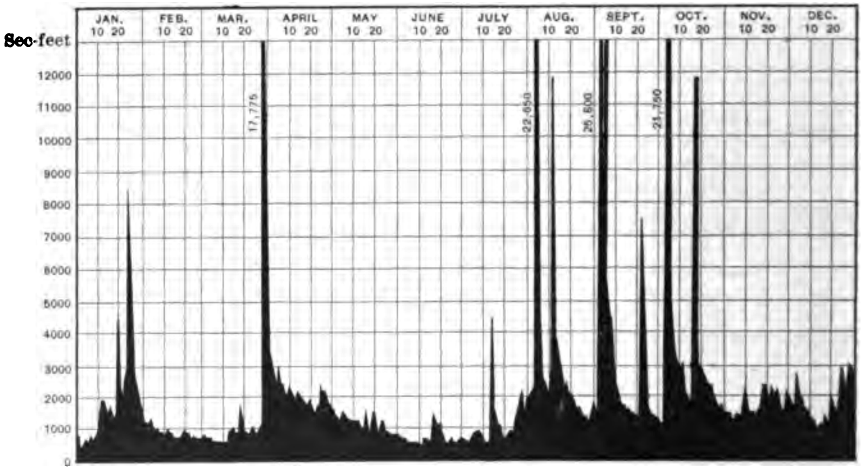

FIG. 42.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE TUCKASEEGEE RIVER, AT BRYSON CITY, N. C., FOR 1898.

JUDSON STATION ON THE LITTLE TENNESSEE RIVER.

This station is located on the Southern railway bridge, about one-fourth of a mile below Judson and above the mouth of Sawyer branch. The zero of the gauge-rod is 25 feet west of the east end of the second span from the east. The outer rim of the pulley-wheel is 2 feet from the zero of the gauge-rod, and the distance from the end of the weight to the pointer on the wire is 26.25 feet. The gauge reads zero when the weight touches the bottom of the river. On the west side of the stream the bottom is rocky and very rough; on the east side sandy, and the current is very swift. The river is straight for several hundred yards above and below the station. The section is not a very good one as there are two bad pier obstructions. The observer is R. C. Sawyer, Judson, N. C.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

LIST OF DISCHARGE MEASUREMENTS MADE ON LITTLE TENNESSEE RIVER AT JUDSON, NORTH CAROLINA.

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	June 25	E. W. Myers	21	2.76	345	2.69	929
2	Sept. 23	....do	2154	3.00	286	2.71	775
	1897.						
3	Aug. 21	E. W. Myers	2154	3.21	278	2.78	771
4	Oct. 13	....do	2154	2.75	247	2.83	701
5	Oct. 23	A. P. Davis	94	2.44	207	2.77	448
	1898.						
6	Sept. 6	E. W. Myers	9	7.30	920	10.67	9,821

RATING-TABLE FOR LITTLE TENNESSEE RIVER AT JUDSON, NORTH CAROLINA.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
2.0	225	4.0	2,650	6.0	6,750	8.4	13,700
2.1	250	4.1	2,835	6.1	6,995	8.6	14,475
2.2	300	4.2	3,020	6.2	7,240	8.8	15,275
2.3	370	4.3	3,205	6.3	7,485	9.0	16,100
2.4	445	4.4	3,390	6.4	7,730	9.2	16,950
2.5	525	4.5	3,575	6.5	7,975	9.4	17,825
2.6	610	4.6	3,770	6.6	8,240	9.6	18,725
2.7	705	4.7	3,965	6.7	8,505	9.8	19,500
2.8	805	4.8	4,160	6.8	8,770	10.0	20,600
2.9	925	4.9	4,355	6.9	9,035	10.2	21,600
3.0	1,060	5.0	4,550	7.0	9,300	10.4	22,600
3.1	1,205	5.1	4,760	7.1	9,580	10.6	23,600
3.2	1,360	5.2	4,970	7.2	9,860	10.8	24,600
3.3	1,515	5.3	5,180	7.3	10,140	11.0	25,600
3.4	1,670	5.4	5,390	7.4	10,430	11.2	26,600
3.5	1,825	5.5	5,600	7.5	10,700	11.4	27,600
3.6	1,990	5.6	5,830	7.6	11,010	11.6	28,600
3.7	2,155	5.7	6,060	7.8	11,600	11.8	29,600
3.8	2,320	5.8	6,290	8.0	12,275	12.0	30,600
3.9	2,485	5.9	6,520	8.2	12,975	....	.....

Estimated Discharge of the Little Tennessee river, at Judson, North Carolina

[Drainage area, 738 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
July	14,805	705	3,614	222,218	6.08	4.89
August	2,408	725	1,285	76.458	2.01	1.74
September	1,515	290	698	41,236	1.04	0.94
October	1,205	550	684	42,057	1.06	0.92
November	11,300	686	2,351	139,895	3.54	3.18
December	11,300	1,639	3,542	217,797	5.53	4.80
					19.21	2.74
1897.						
January	4,199	1,670	2,390	146,951	3.73	3.24
February	14,185	1,852	4,575	254,084	6.44	6.19
March	16,195	1,875	7,750	447,027	12.18	10.51
April	11,930	1,278	4,365	259,738	6.58	5.90
May	4,991	1,389	2,449	150,587	3.83	3.32
June	4,160	939	1,968	117,100	2.94	2.64
July	4,970	1,515	2,376	146,222	3.71	3.22
August	2,658	775	1,640	100,843	2.56	2.22
September	925	392	719	42,783	1.08	0.97
October	3,723	334	829	50,978	1.29	1.12
November	1,515	430	792	47,127	1.19	1.07
December	3,751	565	1,528	93,955	2.38	2.07
					47.91	3.54

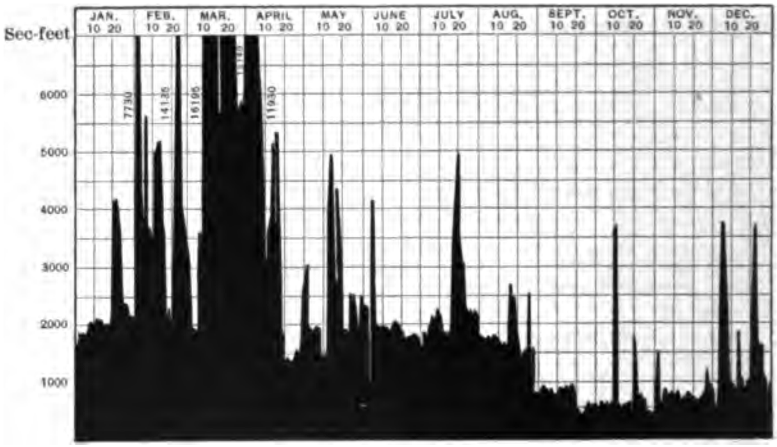

FIG. 43.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE LITTLE TENNESSEE RIVER, AT JUDSON, N. C., FOR 1897.

Estimated Discharge of the Little Tennessee river, at Judson, North Carolina.

[Drainage area, 738 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	5.784	686	1 495	91,926	2.33	2.02
February	1,220	370	759	42,152	1.07	1.03
March	13,160	370	1,781	109,511	2.78	2.41
April	6,244	1,060	2,411	143,464	3.63	3.26
May	3,075	300	1,882	115,722	3.04	2.55
June	785	300	563	33,500	0.84	0.76
July	8,797	265	1,250	76,862	1.95	1.69
August	22,500	1,593	5,836	358,843	9.10	7.90
September	30,250	1,701	5,187	308,646	7.83	7.02
October	45,600	1,732	6,093	374,648	9.51	8.25
November	3,750	2,369	2,902	172,673	4.38	3.93
December	4,543	1,825	2,184	134,185	2.41	2.96
The year	45,600	265	2,695	1,955,082	48.87	3.65

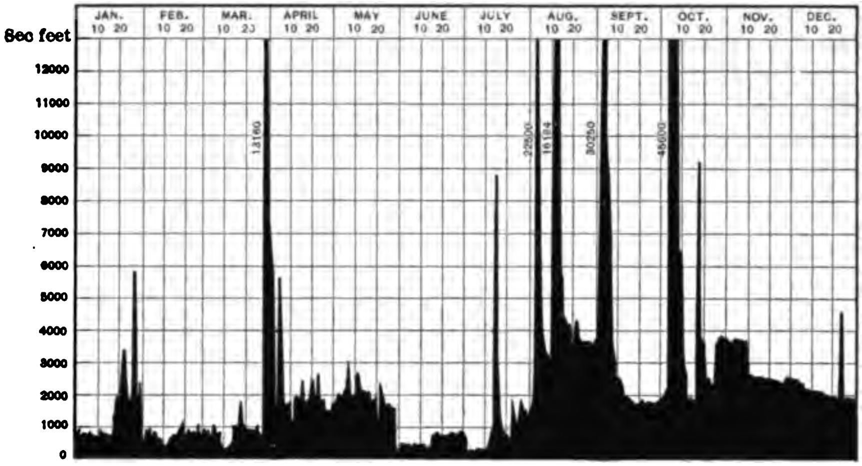

FIG. 44.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE LITTLE TENNESSEE RIVER, AT JUDSON, N. C., FOR 1898.

MURPHY STATION ON THE HIWASSEE RIVER.

This station is located on the highway bridge crossing the river at Murphy, North Carolina, one-half mile above the mouth of Valley river. The zero of the gauge-rod is 8 feet north of the center of the second full-length compression member from the north end of the bridge and on the down-stream side. The outer rim of the pulley-wheel is 2 feet from the zero of the rod, and the distance from the end of the weight to the marker on the wire is 29.1 feet. The reading of the gauge is zero when the weight touches the bottom of the stream. The section here is a good one, though somewhat obstructed by the remains of two old piers directly under the present bridge. The course of the river is straight for several hundred yards above and below the station and the current is fairly rapid. The bottom is hard and rocky and is not subject to any decided change by high water and the banks are high.

During 1897 the wire gauge was twice cut and was replaced each time according to the figures for the elevation of the bench mark. On the final replacing, October 20, 1897, it was discovered that there was a difference of a foot between the old and the new data. At the time of the establishment of the station a tape was used which was broken at about the 1-foot mark, and it is thought that the allowance of this amount was not made in reporting the elevation of the bench mark. The discharges for 1896 and till October, 1897, are calculated on this supposition, and there is liability to error for the higher stages of flow, as no extreme flood height gaugings have been made. These figures are then to be taken as only an approximation.

The tables of daily gauge height for this station for 1896 and 1897 will be found in Water Supply and Irrigation Papers Nos. 11 and 15, published by the U. S. Geological Survey.

List of Discharge Measurements made on Hiwassee river at Murphy, North Carolina

No.	Date.	Hydrographer.	Meter No.	Gauge height (feet).	Area of section (square feet).	Mean velocity (feet per second).	Discharge (second-feet).
	1896.						
1	June 23	E. W. Myers	21	3.82	311	1.17	366
2	Aug. 10	....do	2154	3.95	278	1.37	382
3	Sept. 22	....do	2154	4.01	353	1.46	517
	1897.						
4	Aug. 20	E. W. Myers	2154	5.23	308	1.71	528
5	Oct. 14	....do	2154	4.76	264	1.01	267
6	Oct. 29	A. P. Davis	94	4.71	277	0.91	253
	1898.						
7	Jan. 21	E. W. Myers	2154	6.05	490	2.61	1,170
8[1]	Sept. 8	....do	9	6.80	634	2.56	1,620

Rating-Table for Hiwassee river at Murphy, N. C., from July, 1896, to August, 1897.

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
3.4	135	4.2	540	5.0	1,130	5.8	1,790
3.5	175	4.3	605	5.1	1,210	5.9	1,875
3.6	215	4.4	675	5.2	1,290	6.0	1,950
3.7	260	4.5	745	5.3	1,370	7.0	2,810
3.8	310	4.6	820	5.4	1,450	8.0	3,660
3.9	360	4.7	895	5.5	1,535	9.0	4,510
4.0	415	4.8	970	5.6	1,620	10.0	5,510
4.1	475	4.9	1,050	5.7	1,705	....	.....

Rating-Table for Hiwassee river at Murphy, North Carolina.

[Applicable from October 20, 1897, to December 31, 1898.]

Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.	Gauge height.	Discharge.
Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.	Feet.	Sec.-feet.
4.6	225	5.4	570	6.2	1,320	7.0	2,120
4.7	250	5.5	640	6.3	1,420	7.1	2,220
4.8	280	5.6	720	6.4	1,520	7.2	2,320
4.9	315	5.7	820	6.5	1,620	7.3	2,420
5.0	350	5.8	920	6.6	1,720	7.4	2,520
5.1	400	5.9	1,020	6.7	1,820	7.5	2,620
5.2	450	6.0	1,120	6.8	1,920	....	......
5.3	510	6.1	1,220	6.9	2,020	....	......

[1] Meter damaged.

ESTIMATED MONTHLY DISCHARGE OF HIWASSEE RIVER AT MURPHY, NORTH CAROLINA.
[Drainage area, 410 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
July [1]	3,848	260	792	48,799	2.22	1.93
August	481	238	320	19,709	0.90	0.78
September	540	199	241•	14,339	0.65	0.59
October	360	179	237	14,597	0.68	0.55
November [1]	3,188	208	646	38,437	1.76	1.58
December	1,290	360	500	30,795	1.41	1.22
					7.57	1.11
1897.						
January	1,210	360	556	34,244	1.56	1.35
February [1]	2,727	488	1.092	60,650	2.77	2.66
March [1]	4,610	745	1,824	112,340	5.13	4.45
April [1]	3,320	820	1,328	79,116	3.61	3.24
May	1,130	540	683	42,066	1.91	1.66
June	605	415	464	27,608	1.26	1.13
July [1]	8,510	335	813	49,991	2.28	1.98
August [2]	640	475	556	7,515	0.26	1.35
September [3]	....	....	....	....	....	....
October [4]	350	237	268	6,380	0.29	0.65
November	570	315	342	20,350	0.93	0.83
December	2,470	350	737	45,316	2.08	1.80
The year	8.510	237	788	515,776	22.07	1.92

ESTIMATED MONTHLY DISCHARGE OF HIWASSEE RIVER AT MURPHY, NORTH CAROLINA.
[Drainage area, 410 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1898.						
January	2,320	400	899	55,277	2.53	2.19
February	720	462	543	30,157	1.37	1.32
March	6,220	450	895	55,031	2.52	2.18
April	3,870	770	1,281	77,225	3.48	3.12
May	920	400	612	37,698	1.72	1.49
June	640	332	406	24,159	1.10	0.99
July	1,320	315	631	38,799	1.78	1.54
August	6,980	720	1,712	105,268	4.80	4.17
September	13,580	720	1,976	117,576	5.41	4.82
October	10,060	640	1,948	119,780	5.47	4.75
November	1,820	840	1,086	64,617	2.94	2.64
December	1,220	820	980	60,258	2.75	2.39
The year	13,580	315	1,081	785,840	35.87	2.63

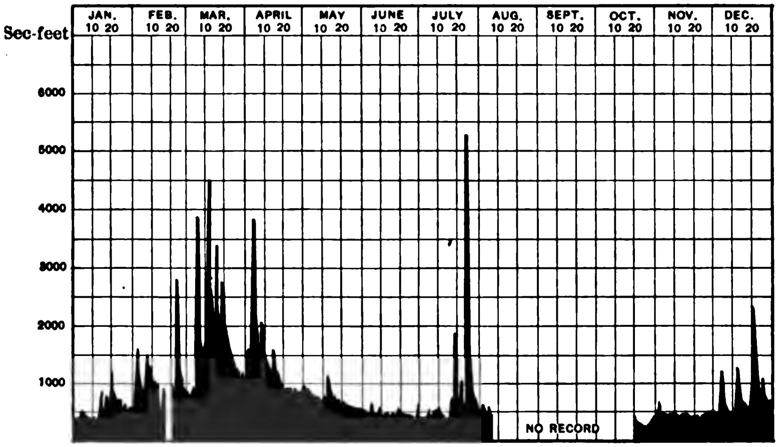

FIG. 45.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE HIWASSEE RIVER, AT MURPHY, N. C., FOR 1897.

[1] Maximum estimated. [2] 7 days' record. [3] No record. [4] 12 days' record.

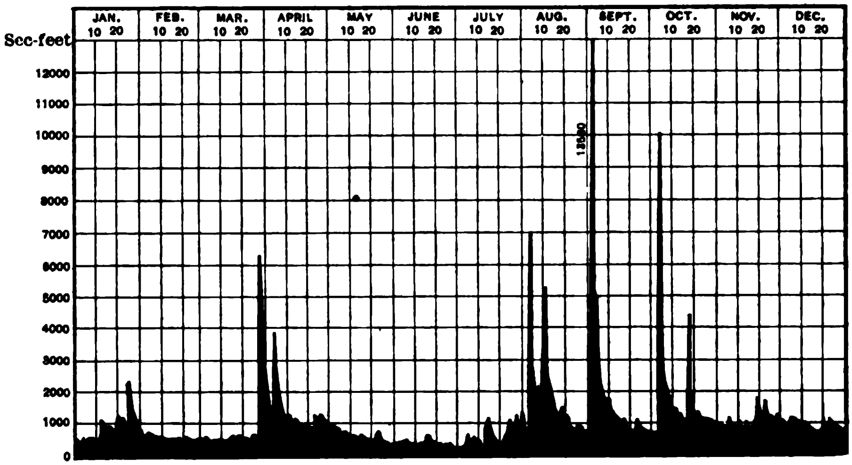

FIG. 46.—DIAGRAM OF THE DAILY MEAN DISCHARGE IN CUBIC FEET PER SECOND OF THE HIWASSEE RIVER, AT MURPHY, N. C., FOR 1898.

PART V

ELECTRIC POWER TRANSMISSION

By J. W. Gore

ELECTRIC POWER TRANSMISSION.

CHAPTER XVI.

ELECTRIC POWER TRANSMISSION.[1]

A question of great importance with every manufacturing enterprise is the cost of power, since, in many such industries, labor constitutes the largest item in the cost of the products, and in none is it to be disregarded.

SOURCES OF ENERGY FOR OPERATING MACHINERY.

The sources of energy upon which man relies for operating machinery and doing useful work are few: fuel, waterpower, wind, solar radiation. We are practically limited to the first two, fuel and waterpower. The wind is used to a very limited extent, as it is too uncertain and intermittent to meet the usual requirements of a source of power, and, though solar radiation furnishes an enormous amount of energy, yet, as a source of power for directly operating machines, it remains practically unused.

Sometimes one or the other of the two available forms of energy is to be found at or near the raw material, yet more frequently the material has to be transported to the power or the power transmitted to the material. The location of many of our manufacturing towns has been decided by desirable and ample waterpowers or the abundance and cheapness of fuel, without reference to the nearness of the raw materials or the markets for the finished products. But as the item of cost of labor lessens by improvements in machinery and methods of manufacture, the item of cost of transportation constitutes a larger per cent. of the cost of the finished product; hence the question of conveying the power to the material or conveying both power and material to some advantageous point grows in importance.

DIFFERENT MEANS OF TRANSMITTING POWER.

The means employed for conveying or transmitting power for distances exceeding a few hundred feet, other than by hauling fuel, are: cables, compressed air, hydraulic pressure and electricity.

The hydraulic system of transmitting power is limited to a special class of work under favorable circumstances, and hence need not here be compared with the other methods of power transmission.

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[1] By J. W. Gore, Professor of Physics, University of North Carolina.

In a recent book, "Electric Power Transmission," by Dr. Louis Bell, the three systems of power transmission—rope, pneumatic and electric—are compared. He assumes that 100 horsepower is developed by a steam plant, then transmitted two miles and delivered as a unit by each of these systems, the conditions under which they are operated being such as may be found in the practical working of the respective systems. The following table gives the data needed for a comparison. Under the head of operating expenses are included attendance, maintenance and interest on the money invested:

System.	Efficiency.	Total cost.	Operating expense.	Cost per horsepower per year.
Rope..........	67%	$92,000	$33,500	$49.00
Pneumatic	54	82,000	26,000	48.00
Electric	73	84,000	27,000	38.00

The great difference in cost of the power delivered in favor of electric transmission would be increased had a higher efficiency been assigned the electrical equipment—an efficiency of 80 to 85 per cent. being now commonly attained; and, also, if a comparison were made when the systems were operating at less than full load.

Had the distance of transmission been limited to one mile the probability is that the rope and the electric systems would have delivered the power at practically the same cost.

Both the pneumatic and electric systems have the advantage over rope transmission when the power is to be divided into several units instead of being delivered as one unit.

DEVELOPMENT OF ELECTRIC POWER TRANSMISSION.

Electric power transmission had its commercial beginning in 1837 with the introduction of Morse's system of telegraphy, the amount of energy transmitted being small and the cost quite high, but it has only been since the invention of the modern machines for generating electricity in large quantities, and so much more cheaply than by the use of primary batteries, that the use of this form of power and its transmission have become such important factors in the commercial world.

It is to street-car traction and lighting, two demands for energy in which the margins of profit are sufficiently wide to assure capital of a fair return on investment, that we are mainly indebted for the stimulus to the inventors and manufacturers of generators and motors, together with their various accessories, which has resulted in so brief a time in producing the highly efficient electrical machinery in operation to-day.

In the lighting industry the generator has proven its reliability and durability; the regulation and distribution of the current is completely solved, and the great rapidity with which the electric system of lighting has been extending is ample proof of efficiency and economy.

The successful application of motors to the severe and varying requirements of the motive power for street cars demonstrates their ability to endure rough treatment, and the readiness with which they can respond to the changing demands for power.

DISTRIBUTION OF POWER IN THE FACTORY. ELECTRICITY COMPARED WITH SHAFTS AND BELTS.

In manufacturing plants of any size, power is needed at several more or less widely separated points, and as it is more economical to generate the power in large units than in several small ones, it becomes necessary to transmit the power from the place where it is generated to the several points where it is to be employed.

This distribution of power through the mill or factory is usually accomplished by shafts and belts.

Without considering the cost of shafts and belts, the troubles that arise when shafts get out of alignment, or the annoyance of slipping belts, the dust they stir up and the room they occupy, we may briefly consider the efficiency of distributing power by shafts and belts, and compare with it the efficiency of power-distribution by electricity.

The loss of power when transmitted by shafts depends upon several conditions besides accuracy of the construction of the line of shafting; such as distance, size of the units of power delivered at the several points, whether the line is straight or is angular, etc.

From the most reliable sources we learn that it is exceptional to find the loss of power at full load to be as small as 25 per cent. in its transmission by shafts from engine to driven machine, and that from 30 to 50 per cent. is the more usual loss. At half load and less, as much as 75 to 80 per cent. may be lost in transmission.

Should the power be transformed into electricity by a direct-connected generator of moderately large size, distributed by conducting wires of proper size to motors ranging in size from 5 to 15 horsepower the efficiency would be about 78.6 per cent., since the efficiency of the generator would be 92 per cent., the line 97 per cent., and the motors would have an average efficiency of about 87 per cent Even at half load or less the efficiency of the electric-motor system would probably not fall below 70 per cent.

In large plants the difference in the efficiency of transmission of power by shafting, even assuming it to be as high as 70 per cent., and electric transmission with an efficiency of 78 per cent., means a large difference in operating expense. If the plant is not run at full load the difference in efficiency in favor of the distribution by electricity is far greater.

There are other questions besides efficiency to be considered in deciding in favor of either system. The cost of the installation of the electric system would doubtless be the greater in all cases except under extraordinary conditions. However, there would be a saving in cost of buildings, as the wires take up practically no room and do not need special foundations as shafting does. Then, too, the cost of maintenance is less, and certain classes of machines do more work when operated by separate electric motors under the immediate control of the operator than when dependent on the common power of the mill or factory.

It is readily seen that many points would have to be considered in any given case before deciding in favor of either method of distributing power, when the greatest efficiency and economy is the aim, and the means for installing either system of transmission are available.

FACTORIES OPERATED BY ELECTRICALLY TRANSMITTED POWER.

A few examples of the distribution of power by electricity will suffice to prove that the great efficiency claimed is not theoretical only, but has the endorsement of capital, and hence must be profitable.

A fire-arms factory at Herstal, Belgium, is operated by electric motors, supplied by electricity from a generator, direct-coupled to a 500 horsepower steam-engine. There are 17 motors distributed through the factory with an aggregate capacity of 305 horsepower. The efficiency of the system from the shaft of the engine to the pulley of motors is 77 per cent. The installation has given such satisfactory results that the plant has been enlarged by the addition of another such unit.

The motor has been tried at the Dunnell Print Works in Pawtucket, operating a seven-roll printing-machine. It is said that printing-machines present the greatest difficulties in the application of power of any machinery in textile manufacture, requiring varying speed without shock in the gradations, frequent stopping and an excess of power to start.

It is stated that the production of this machine is at least 33⅓ per cent. greater, driven by an electric motor, than when run by steam-power. After a trial of eighteen months Mr. Dunnell was so thoroughly convinced of the superiority of electricity as the motive power for this class of work that he advised the employment of the electrical system of distribution and application of power in all new print-works that may be constructed.

The Page Belting Company, Concord, N. H., substituted electrical distribution of power for shafting in their extensive mills, and found it cheaper and more efficient.

In this instance, according to the statement of the president of the company, the installation of the electrical plant was cheaper than a steam plant, capable of accomplishing the same amount of work.

Probably we would not have had this direct comparison of cheapness of the two systems of distributing power generated by steam had it not been the expectation of the company to use electricity developed by waterpower at Sewalls falls on the Merrimac river, four miles north of Concord. This waterpower, of 5000 horsepower, has been developed, and the belting mills are equipped to use 2000 horsepower of the electrically transmitted energy.

An interesting case, in which the questions of transmission and the distribution of power were somewhat equally prominent, is afforded by the power plant of the Columbia Cotton Mills, Columbia, S. C. The waterpower is obtained from a canal, built many years ago, for transporting boats past the rapids in the river. Between the canal and river is barely room for the power house, and a desirable location for the mill is on the opposite side of the canal, 800 feet from the power house. Had it been simply a question of transmitting the power this short distance and employing it as one unit, the chances are that rope transmission would have been adopted, but upon considering also the distribution of the power through the mill, it was decided that electrical transmission and distribution was the more efficient and economical method. The power plant consists of two turbine water-wheels, direct connected, with two 500 kilowatt, three-phase generators, two 10 horsepower direct-current generators to excite the fields of the large generators, an electric water-governor and switchboard. The current is carried to the mill by cables placed under ground and distributed in the mill to 17 motors of 45 horsepower each. The motors make 540 revolutions per minute, start with full load, and will not stop if overloaded up to 125 horsepower. Being rotary-field motors, there is no rubbing contact and hence no injurious or dangerous sparking. The efficiency of the transmission of power from the shaft of the turbines to the pulley of the motors is between 75 and 80 per cent. The mill was started June 22, 1894, and has been in continuous operation ever since, the power transmission and distribution meeting the expectation of the General Electric Company that put in the electrical installation, and fulfilling the requirements of the owners of the mills. (Plate XV—B.)

One of the most complete electric-power distribution plants that may be cited is doubtless the one that has recently been installed in the Government Printing Office, Washington, D. C. A small electric plant was put in over a year ago as an experiment, and the public printer was so completely convinced of the reliability and efficiency of the electric system that the entire office has been equipped with this service. The power house is supplied with three engines and generators designed to run thirty days without shutting down, and to regulate so perfectly that the lights will not perceptibly vary under any change of load. The current generated supplies 4000 16 candle-power lamps and 167 motors, aggregating 579 horsepower. The motors are direct-connected to the presses and also to many of the other machines. The production of the presses has been increased many per cent. and the character of the work much improved, due largely to the constant speed of the motors. Among the many advantages derived from the application of motors to the machinery of this great establishment may be mentioned the removal of miles of belting which cut off a great deal of light, and many tons of shafting and pulleys, which produced a great deal of noise and dirt, besides the great strain on the floors.

The efficiency of electrical distribution has been dwelt upon because it enters as an important factor in the more general question of electric-power transmission.

RELATIVE COST OF DIRECT STEAM-POWER AND ELECTRICALLY TRANSMITTED POWER.

The cost of power provided by each of the two methods must be ascertained by a careful determination of the existing conditions in any particular case. That is, an accurate estimate should be made of the cost of a power-transmission plant, its efficiency and expense of maintenance and operating it; also a similar estimate for a steam plant.

While it is only possible to compare the cost of supplying power by these two ways for an average condition of things, yet this may be of service in calling attention to the probability of a given waterpower being economically available, as it may lead to the investigation of questions which will doubtless result in developing some of the unused waterpowers of the state.

COST OF INSTALLING AND OPERATING ELECTRICAL PLANTS.

The data used in the following estimates are obtained from reliable sources, and illustrate the various items of cost that obtain under average conditions: cost of installing a power-transmission plant of 100 horsepower; distance of transmission 10 miles; voltage 5000, total efficiency 80 per cent.:

Hydraulic work, including wheels, etc.	$6,000.00
Generators and switchboard	2,500.00
Power-house	1,000.00
Line	3,500.00
Miscellaneous	1,000.00
Total	$14,000.00

Operating Expenses:

Interest and depreciation @ 10%	$1,400.00
Attendance	750.00
Maintenance	1,200.00
Interest @ 5% on cost of water rights	200.00
Total	$3,550.00

This calculation gives $3,550 as the cost of 80 horsepower delivered, or at $44.37 per horsepower per year.

Taking a larger unit, say, 1000 horsepower; transmission 10 miles; voltage 1000; total efficiency 80 per cent., we would have:

Hydraulic work, wheels, etc	$55,000.00
Generators	25,000.00
Power-house	2,500.00
Line	7,500.00
Miscellaneous	10,000.00
Total	$100,000.00

Operating Expenses:

Interest and depreciation @ 10%	$10,000.00
Attendance	3,000.00
Maintenance	6,000.00
Interest on cost of water rights @ 5%	2,000.00
Total	$21,000.00

Cost per horsepower per year of $26.25.

The General Electric Company gives as the result of its experience in Circular No. 1008, "Electrical Transmission of Power," the following as a fair average cost of installing a plant:

Development of waterpower	$50.00	per H. P.
Generators, switchboard, and power-house	40.00	"
Line	25.00	"
Water rights and incidentals	60.00	"
Total	$175.00	"

The efficiency of transmission being 80 per cent., the cost would be nearly $220 per horsepower delivered. Allowing 15 per cent. for depreciation and operating expenses, we have a total cost per electrical horsepower per year of about $33.

The cost increases some with distance, but not very much, until the distance reaches some forty or fifty miles, for by increasing the voltage, the cost of the copper may be kept practically constant and the poles should not cost over $250 per mile.

Under favorable conditions the cost of transmitted power may be very much less than the above estimates indicate. A recently installed plant near Butte, Montana, for developing 5000 horsepower and transmitting 75 per cent., or 3750 horsepower, 21 miles, cost, complete, $400,000, or $106.66 per horsepower. Estimating operating expenses at 15 per cent., would give the power ready for distribution at $16 per horsepower per year.

COST OF INSTALLING AND OPERATING STEAM PLANTS.

From the time during which steam-power has been employed, it would naturally be supposed we would have definite data for computing its cost when the price of fuel is given. Accurate tests have frequently been made, and the results may be relied upon, provided the conditions under which the tests were made are maintained. But there is such a variety of boilers, with such varying ratios of grate surface to heating surface, and ratios of either to the amount of water to be converted into steam, that the problem is in general of uncertain solution. Then the rate of combustion of the fuel is a varying quantity, as also the temperature at which the products of combustion are allowed to escape into the air. The condition of the atmosphere, whether it is moist or dry, light or heavy, effects the burning of the fuel.

Users of steam-power rarely have a definite knowledge of what it costs them per horsepower. They doubtless know the amount of bills for fuel, wages, interest on plant, taxes, supplies and incidentals, but the unknown quantity is the amount of power that has been generated at the shaft of the engine. Usually the estimate per horsepower per year, if made, is computed on the rated horsepower of the engine without considering that the chances are that they were actually obtaining an average of only a comparatively small fraction of the nominal capacity of their plant.

The nearest we can come to a satisfactory solution of the cost of steam-power is to give the results of those who have made the subject a special study and have determined the cost under stated conditions.

The following table, giving the cost of steam power per horsepower per year, is a summary of the researches on this subject by Dr. C. E. Emory.

Capacity of engine 500 horsepower, run at full load for 10 hours a day, 308 days per year:

Kind of engine.	Coal $3.00 per ton.	Coal $4.00 per ton
Simple low speed..............	$34.20	$39.94
Simple low speed, condensing ..	26.77	30.73
Compound, condensing	25.53	29.09

In ordinary practice the real cost would be from 25 to 50 per cent. more than that given in the table, since it is unusual for engines to run continuously at full load, and even when they do, the stoking is likely to be carelessly done, and it is most certain that the average engine does not measure up to its rating.

After considering the efficiency of the various forms and classes of heat engines, Dr. Louis Bell summarizes results as follows, coal being taken at $3 per ton:

Kind of engine.	Cost per horsepower hour, fully loaded.	Cost per horsepower hour, partial load.
Large compound, condensing	0.8 c. to 1 c.	1 c. to 1.5 c.
100 horsepower, simple	1.5 c. to 2.5 c.	3 c. to 5 c.
20 horsepower, and less, simple...	7 c. to 12 c.	12 c. to 20 c.

Taking an average from the data given, and from other equally reliable sources, it is safe to say that steam-power will cost between $30 and $50 per horsepower per year of 3080 hours, using engines of 250 horsepower and over, while engines of, say, 100 horsepower, will put the cost at from $45 to $75.

ADVANTAGES IN FAVOR OF ELECTRICALLY TRANSMITTED POWER.

In connection with the relative cost of delivering power electrically transmitted and by steam, the advantages of electrical distribution must be considered.

The convenience, safety and economy of space of the motor are sufficient to decide in favor of the use of electricity even when it can be obtained no more cheaply than steam-power.

Indeed, there are very few places where steam-power can be developed cheap enough to prevent electric-power finding a market in small amounts, even at $50 to $75 per horsepower per year.

When the power is used 24 hours a day the advantage of electrically transmitted power becomes much more decided. In a steam-plant all the items in the expense of operating increase in proportion to the time of running except interest on the plant, taxes and insurance, while with the transmission plant only attendance, depreciation and incidentals increase in proportion to the time.

Since at least three-fourths of the operating expense of a steam plant is increased in proportion to the time of running, it is easily shown that the cost per horsepower for a 24-hour day is slightly more than double the cost for a 10-hour day, while electrically transmitted waterpower is only increased a little more than one-third for the increased time.

The Niagara Falls Power Company has offered developed waterpower at $13 per horsepower per year, and electric-power at the generator at $18. Assuming that its transmission to Buffalo cost as much as generating the electricity, or $5 per horsepower, we would have the cost of electrical power at Buffalo $23 per horsepower per year, of 308 days and 24 hours per day.

A careful estimate of the cost of steam-power in Buffalo was made before introducing electricity generated at Niagara, and found to be from $45 to $60 per horsepower per year (24-hour days), the units being large and coal very cheap.

The only exact method of comparing the cost of power supplied by the two sources we are considering would be by ascertaining the cost of the products of a mill or factory operated by a transmission plant and the cost of similar products of a mill or factory at the same place operated by steam. Such a comparison would include the efficiency of the machines run by the different sources of power as well as the cost of power. Such statistics are difficult to obtain, as manufacturers do not advertise the cost of the products of their mills.

From the number of power transmission plants installed within the past few years and the rapidly increasing demand for electric power, we are assured that in many cases at least there is a decided margin of profit in favor of electrically transmitted power. It might be said that it is the fashion now to use electricity for all power purposes were it not an assured fact that capital invested in industrial enterprises expects a return in kind.

SOME TYPICAL MANUFACTURING PLANTS USING ELECTRICALLY TRANSMITTED POWER.

A brief reference to a few plants that have been in operation for a longer or shorter time may illustrate the efficiency and reliability of this kind of power, as well as the various conditions under which it may be used and the distance transmitted.

The first of these plants to be installed was by S. D. Warren & Co., Cumberland Mills, Maine. Their paper mills were at first driven by waterpower; upon enlarging the mills, steam was employed. In 1891 they developed a waterpower one mile lower down the stream and installed four 80 horsepower Mather generators, and put six 40 horsepower motors in the mills. The plant has been continuously in operation since it was started, running 24 hours per day, and has given satisfaction, both as to efficiency and cost. As a result of their experience, they have, within the past three years, developed a waterpower of 500 horsepower at a distance of five miles. This installation consists of two 250 horsepower alternating-current generators, each driven by two water-wheels. The current is transmitted at 7600 volts, transformed at the mills to 400 volts and distributed to the motors, doing various kinds of work. This addition to their power was not called for by an enlargement of the mills, but because electrically transmitted power proved to be cheaper than steam, even though their steam plant is to a considerable extent idle.

Another electrical power plant which has been in operation long enough to give reliable results is furnishing part of the motive power for running the Nonatuck silk-mills at Leeds and Haydensville, Mass. These mills were first run by waterpower, then steam was added, and about seven years since a waterpower was developed and transmitted electrically to the mills. This waterpower had not been developed previously, as the narrow gorge through which the small river runs at this point does not offer a favorable location for a mill. The generator station is of special interest because of its compactness. Three water-wheels are in one case. One wheel drives two generators, which supply current for 1000 lights in the mills; another wheel drives two 500-volt Thompson-Houston generators, which supply current at the Leeds mill, one-half mile distant, to drive a 45 horsepower motor belted to the main shaft, to which is connected the water-wheels of the mill and also a steam engine when needed; and it also furnishes current for two motors of 20 horsepower each and one of 10 horsepower, which drive machinery in separate rooms not connected with the other sources of power. The Haydensville mill, one and a half miles distant, receives current to drive a 45 horsepower motor, which is belted to the main shaft as at Leeds. Connecting motor and engine to shaft with water-wheels has proved very satisfactory, each supplying its quota of power and also acting as a regulator. The efficiency of the machines run directly by motors has been so much increased that it is probable the company will distribute all the power electrically. These mills only run 10 hours a day and coal is quite cheap, $4 per ton in the furnace. The plant has fulfilled the expectation of the company and has given satisfaction.

The Sampson Cordage Company, at Shirley, Mass., has been transmitting 50 horsepower a distance of a half mile since 1893, using a 500-volt, direct-current generator. The interesting feature of this small power plant is the dispensing with the services of an attendant at the generator station. The water is turned on in the morning and off at the end of the day; the regulation, while in operation, is accomplished by the aid of electricity by the attendant at the motor end of the line. Small streams of water are numerous, of sufficient fall, to allow several generating stations to be located within short distances of each other, and the power from all transmitted to a common point sufficient to operate a large mill. Since all the generators may be regulated by one attendant at the motor end of the system, the cost of the power thus assembled should, in many cases, be less than the cost of steam-power.

At the Columbia Cotton Mills, Columbia, S. C., which have already been referred to (p. 341), since the distance of transmission is so small (800 feet), the distribution of the power was as important an element as its transmission in determining the system to be employed.

The Columbia Waterpower Company, Columbia, S. C., has recently completed an installation of a 3000 horsepower plant, which may be increased to 10,000 horsepower. It consists of three turbines of 1250 horsepower each, three 750 kilowatt generators (3-phase alternators, 3540 volts) with their exciters, water-governors, switchboards, etc. The Granby mills, manufacturing print cloths, is the largest customer at present. The current is transmitted 1½ miles and reduced by transformers to 550 volts for the motors and to 110 volts for lighting. The installation at the mills consists of four 150 horsepower and one 75 horsepower induction motors and 1200 lights. (Plate XV—B.)

There have been two other important power-transmission plants put into successful operation in South Carolina within the past three years.

The Pelzer Manufacturing Company, Pelzer, S. C., began operating their large mill, No. 4, during the early part of 1896, using electricity generated by a waterpower, developed at a lower dam, 700 feet long and 50 feet high, on the Saluda river, three miles from the mill. The power-station, located on and just below the dam (Plate XV—A) is equipped with three 1000 horsepower, 3-phase, 3300-volt generators, exciters and necessary station apparatus. The installation of the mill consists of 21 induction motors and 1200 lights. Mill No. 3 is also supplied with current for one 400 horsepower motor and two 5 horsepower motors.

During the latter part of 1895 the Anderson Water, Light and Power Company, Anderson, S. C., began the transmission of electricity generated by waterpower on the Seneca river, six miles distant. This was the first long-distance transmission plant in the South, and the 200 horsepower Stanley generator, 5500 volts, was the largest machine in

A DAM AND POWER-HOUSE, SALUDA RIVER, PELZER, S. C.

B—CANAL AND POWER-HOUSE, COLUMBIA, S. C

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the country of so high voltage. The current is used for incandescent and arc lamps and motors. During the past year the Anderson Company has greatly enlarged its transmission plant by installing two 600 kilowatt, 3-phase, 10,000-volt generators, the distance of transmission being 10 miles. The current is supplied to three 300 horsepower synchronous motors in the cotton-mills at 600 volts, 70 arc lights and 1500 incandescents, and several small motors in the town; the total horsepower delivered is reported to be 1425.

The first power-transmission plant in North Carolina has been installed by the Fries Manufacturing and Power Company of Winston-Salem. A waterpower in the Yadkin river, at the crossing of the Mocksville branch of the Southern railroad, has been developed by the erection of a stone dam yielding 1000 horsepower at mean low water, the head being 10 feet. The power-house is placed immediately at the eastern end of the dam. Eight turbine wheels are geared to one shaft, which drives a 750 kilowatt, 3-phase, alternating-current Stanley generator of 10,000 volts. Provision has been made for the installation of another equal unit by the construction of wheel-pits and foundations

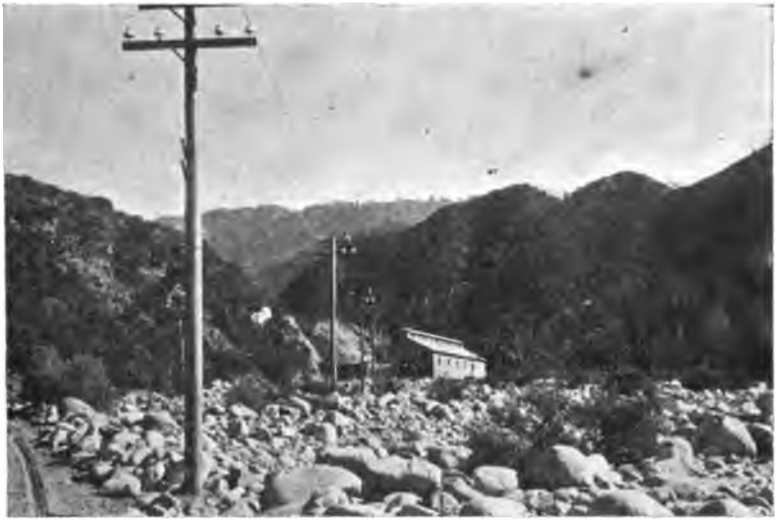


Fig. 47.—Power-house of the Southern California Power Company and transmission line, of which the six No. 1 copper wires are intended to transmit 1000 horsepower each to Los Angeles, a distance of 80 miles. It is said that the generator transmits to the switchboard 96% of the power delivered to it; and that this power (2000 horsepower) is now (Jan., 1899) being transmitted to Los Angeles at a voltage of 33,000 with a loss in transmission of less than 10%.

for another generator. Two water-governors control six of the eight wheels. The electricity is transmitted 13½ miles by three No. 6 bare copper wires. Two barbed iron wires are placed above the copper conductors to protect them from lightning. The upper cross-arms also carry two telephone wires. In the erection of the pole line provision has also been made for the enlargement of the plant. The voltage is reduced at a transformer station in Winston-Salem to 1250 by two sets of transformers, of three each, and distributed to the consumers of power as follows: Arista Cotton Mills, 300 horsepower; Wachovia grain mills, 80 horsepower; F. & H. Fries woolen mills, 80 horsepower; Fogle Bros., 50 horsepower; J. A. Vance, 30 horsepower; Winston-Salem Railway and Electric Company, 300 horsepower. The South Side cotton mill is supplied with current to operate a 300 horsepower motor from the station at 10,000 volts and reduced to 1250 volts by transformers at the mill. The Southern Chemical Company will be similarly supplied with 80 horsepower. These two customers being from 2½ to 3½ miles distant from the station, the voltage is not reduced until the mills are reached. Application for over 200 horsepower more has been made. The rated capacity of the plant has already been exceeded, and to supply the demand the contemplated enlargement will have to be made. (Plate XVI.)

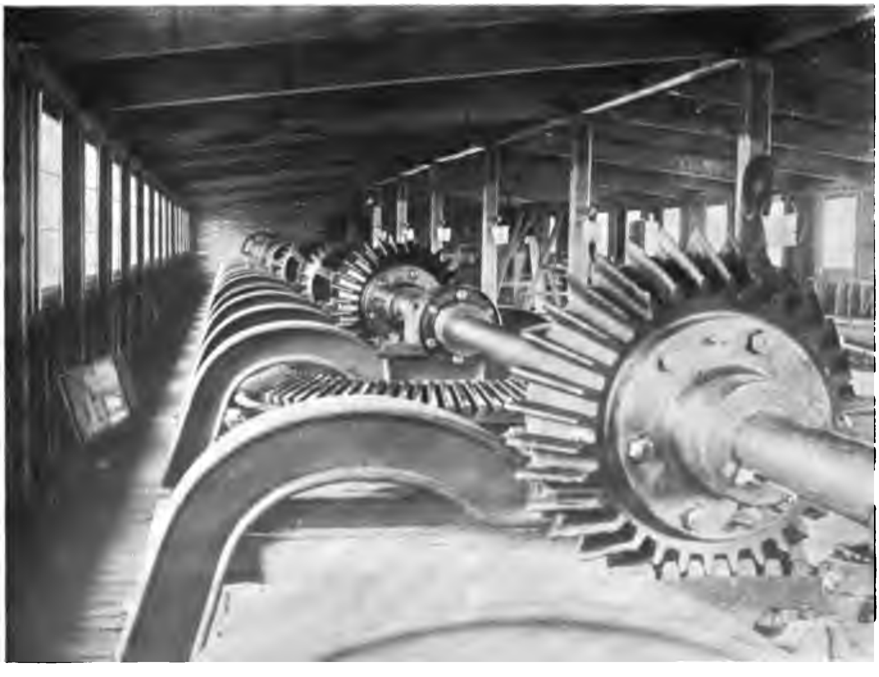
The motors and electrical installation in the various mills belong to the power company. All motors of 50 horsepower and over are of the Stanley synchronous type, while the smaller motors for power and starting purposes are of the Westinghouse induction type. Electricity is sold by the meter at the rate of $20 per horsepower per year, 12 hours per day, with a minimum charge for 25 horsepower. For a 24-hour per day service the charge is $40 per horsepower per year. The tested efficiency of the entire transmission, from shaft of generator to pulleys of motor is 88½ per cent. The cost of the installation so far has been about $125,000.

The plant was started for regular working the latter part of April of the present year.

J. W. GORE.

UNIVERSITY OF NORTH CAROLINA, *July 6th*, 1898.

A—DAM AND POWER-HOUSE, FRIES MANUFACTURING AND POWER CO., ON THE YADKIN RIVER



B.—INTERIOR VIEW, UPPER PART OF POWER-HOUSE, FRIES MANUFACTURING AND POWER CO.

THE GENERATOR IS AT THE FAR END OF THE HORIZONTAL WHEEL SHAFT WHICH IS HERE SHOWN

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